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The World Bank

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Report No. 8379

PROJECT COMPLETION REPORT

KOREA

CHUNGJU MULTIPURPOSE PROJECT
(LOAN 1666-KO)

FEBRUARY 6, 1990

Agriculture Operations Division
Country Department II
Asia Regional Office

CURRENCY EQUIVALENTS

Currency Unit - Korean Won (₩)

APPRAISAL	PROJECT COMPLETION REPORT
US $ 1.00 = ₩ 485.00	US $ 1.00 = ₩ 892.50 (Dec.31.1985)
₩ 1.00 = US $ 0.00206	₩ 1.00 = US $ 0.00112 (Dec.31.1985)

UNITS AND EQUIVALENT

1 meter (m)	= 3.28 feet
1 kilometer (km)	= 0.62 miles
1 hectare (ha)	= 10,000 square meters
	= 2.47 acres
1 square kilometer (sq km)	= 0.386 square miles
	= 100 ha
1 cubic meter (cu m)	= 35.31 cubic feet
	= 1,000 liters (l)
	= 264.2 U.S. gallons
1 million cubic meters (MCM)	= 810 acre - feet
1 megawatt (MW)	= 1,000 kilowatts (kw)
1 gigawatt hour (GWh)	= 1 million kilowatt hours (kWh)
1 kilovolt (kV)	= 1,000 volts (V)
1 ton	= 1,000 kilogram (kg)
	= 2,205 pounds

ABBREVIATIONS

ADC	= Agriculture Development Coperation
DCF	= Discount Cash Flow
ECI	= Engineering Consultants Inc.
El.	= Denotes elevation above mean sea level
EDR	= Equalizing Discount Rate
EPB	= Economic Planning Board
ISWACO	= Industrial Sites and Water Resources Development Corporation
KDB	= Korean Development Bank
KEPCO	= Korea Electric Power Corporation
MCI	= Ministry of Commerce and Industry
MHSA	= Ministry of Health and Social Affairs
MOC	= Ministry of Construction
OECF	= Overseas Economic Cooperation Fund
USAID	= United States Agency for International Development
USBR	= United States Bureau of Reclamation

GOVERNMENT OF KOREA FISCAL YEAR

January 1 - December 31

THE WORLD BANK
Washington, D C 20433
U.S A

Office of Director-General
Operations Evaluation

February 6, 1990

MEMORANDUM TO THE EXECUTIVE DIRECTORS AND THE PRESIDENT

SUBJECT: Project Completion Report on Korea
Chungju Multipurpose Project (Loan 1666-KO)

Attached, for information, is a copy of a report entitled "Project Completion Report on Korea - Chungju Multipurpose Project (Loan 1666-KO)" prepared by the Borrower with an Overview by the Asia Regional Office. No audit of this project has been made by the Operations Evaluation Department at this time.

Attachment

PROJECT COMPLETION REPORT

KOREA

CHUNGJU MULTIPURPOSE PROJECT (LOAN 1666-KO)

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KOREA

CHUNGJU MULTIPURPOSE PROJECT (LOAN 1666-KO)

PROJECT COMPLETION REPORT

Preface

This is the Project Completion Report (PCR) on the Chungju Multipurpose Project in Korea, for which a loan of US$125.0 million was signed on March 29, 1979. The Project was jointly financed with the Overseas Economic Cooperation Fund (OECF) of Japan, which provided a loan of Yen 14 billion or US$70.0 million equivalent. The loan closing date was originally June 30, 1985, but this was extended by six months to December 31, 1985. The final disbursement was made on January 22, 1986. The undisbursed balance of US$1.01 million was cancelled at that time.

This report consists of an Overview, the Basic Data Sheet and the PCR. The PCR of December 1986 was prepared by the Borrower, Industrial Sites and Water Resources Development Corporation (ISWACO) of Korea. The Overview (Highlights), prepared by AS3AG, is based on the attached PCR, the Staff Appraisal Report (No. 1932a-KO dated February 21, 1989), President's Report (No. P-2478-KO dated March 2, 1979), Loan Agreement dated March 29, 1979 and Bank supervision mission reports.

This PCR was read by the Operations Evaluation Department (OED). The draft PCR was sent to the Borrower on November 21, 1989, for comments by December 31, 1989, but none were received.

KOREA: CHUNGJU MULTIPURPOSE PROJECT (LOAN 1666-KO)

PROJECT COMPLETION REPORT - BASIC DATA SHEET

KEY PROJECT DATA

	Appraisal Expectation	Actual or Current Estimate	Actual as % of Appraisal Estimate
Project cost (US$ million)	510.0	602.4	118
Loan amount (US$ million)	125.0	123.9	99
Co-financing (OECF, Japan) (US$ million)	70.0	66.1	94
Date physical components completed	12/84	12/85	
Proportion then completed (%)	100	100	
Economic rate of return (%)	12	13.7	
Financial performance		Satisfactory	
Technical performance		Excellent	

PROJECT DATES

	Original Plan	Actual
Project Brief (Feasibility Study)		July/76
Date of Appraisal mission departure		09/28/77
Date of negotiations		10/16/78
Date of Board approval		03/20/79
Date of Agreement signing		03/29/79
Date of Effectiveness	06/29/79	07/11/79
Loan Closing date	06/30/85	12/31/85

CUMULATIVE DISBURSEMENTS

	FY80	FY81	FY82	FY83	FY84	FY85	FY86
Appraisal estimate (US$ million)	9.80	32.50	62.80	91.20	114.70	125.00	
Actual (US$ million)	6.33	38.45	64.27	83.73	108.34	121.99	123.99
Actual as % of estimate	65	118	104	92	94	98	
Amount cancelled (US$ million)							1.01

Date of final disbursement: January 22, 1986

MISSION DATA

	Date (mo/yr)	No. of Persons	Days in Field	Perform. Status	Rating Trend	Type of Problems
Preappraisal	06/77	6	84			
Appraisal	09/77	5	105			
Subtotal:		11	189			
Supervision 1	07/79	1	7	2	2	T
Supervision 2	11/79	1	21	2	2	F
Supervision 3	07/80	1	13	1	1	
Supervision 4	02/81	1	7	1	2	
Supervision 5	11/81	3	22	1	2	F
Supervision 6	11/82	4	20	2	3	F
Supervision 7	11/83	1	8	1	1	0
		12	98			
		23	287			

OTHER PROJECT DATA

Borrower/Executing Agency	Industrial Sites and Water Resources Development Corp. (ISWACO)
Guarantor	The Republic of Korea
Fiscal year of borrower	January 1 - December 31
Name of currency (abbreviation)	Won (W)
Appraisal year average (1977)	US$1.00 = W 485
Intervening years average (1978-84)	US$1.00 = W 746
Completion year average (1985)	US$1.00 = W 893

Time Recorded (staffweeks)

LEKP	25.0
LEMA	61.0
LEMM	5.0
SPN	23.0
Total:	114.0

Performance Rating STATUS: 1 = Problem-free or Minor Problems, 2 = Moderate Problems, 3 = Major Problems
Performance Rating TREND: 1 = Improving, 2 = Stationary, 3 = Deteriorating
Types of Problems: F = Financial, T = Technical, O = Other than financial/managerial/political/technical

NOTE: Because of inaccurate data recorded in MIS, Days in Field under MISSION DATA and Time Recorded (staffweeks) under OTHER PROJECT DATA present estimated figures based on the supervision reports and other relevant documents on file.

10-Nov-89

KOREA

THE CHUNGJU MULTIPURPOSE PROJECT (LN. 1666-KO)

PROJECT COMPLETION REPORT

HIGHLIGHTS

Introduction

1. The Chungju Multipurpose project has played a key role in the development of the Han River Basin, which covers 26% of Korea's land area and contains 50% of its industry and nearly one-third of its population. The project, consisting of a dam and powerplant on the south branch of the Han River, was needed to satisfy the Basin's rapidly growing demands for municipal, industrial, and irrigation water. It has also helped to meet Korea's growing power demands and has significant flood control benefits. The project was implemented by the Industrial Sites and Water Resources Development Corporation (ISWACO). A loan of $125 million was extended to ISWACO under a loan agreement signed on March 29, 1979. The loan became effective on July 31, 1979 and was closed on December 31, 1985. The final disbursement was made on January 22, 1986. ISWACO also obtained financing of Yen 14,000 million from the Overseas Economic Cooperation Fund (OECF) of Japan.

2. ISWACO prepared the attached completion report which has been reviewed by Bank staff and found to be a fair and thorough account of project implementation and the lessons learned.

The Project

3. History. The project was identified during the Han river Basin Study carried out by the United States Bureau of Reclamation (USBR) in 1971. The object of the survey, financed by USAID, was to formulate a long-range comprehensive plan for developing the Basin's water resources. An important findings of the USBR study was that additional storage would be needed in the Basin by the mid-1980s to supplement the storage provided by existing dams on the north branch of the Han. A feasibility study of the project was carried out in 1976 by Engineering Consultants Incorporated (ECI) of Denver, USA. The project was appraised by the Bank in 1977.

4. Project Features. The main features of the project are a 90 meter high concrete dam on the South Han River, a power house with four 115 MW generating units, and a regulating dam with a 12 MW capacity about 20 km downstream. The project involved the resettlement of 7,100 families living in the reservoir area and compensation for their land and properties, as well as relocation of nearly 300 km of roads and 13 km of railroad.

5. Project Implementation. ISWACO appointed Nippon Koei of Tokyo, Japan as the project consultants. Also, on the recommendation of the Bank, ISWACO secured the services of a three-man consulting panel (a design engineer, a geologist, and a concrete expert). This was the first time a

consulting panel was employed for a major dam in Korea. A special problem in the design of the project involved a large area of unstable rock on the right abutment which was originally identified by ECI during the feasibility study. Close collaboration between the consultants, the panel and ISWACC's engineer led to a solution being incorporated in the contract designs. Hence, a potentially troublesome problem was foreseen and resolved.

6. The principal contracts for the main dam and the reregulating dam were awarded to Hyundae Construction Co., following international competitive bidding. Both contracts were completed on schedule. A joint venture of Daewoo Heavy Industry and Toshiba Corporation won the contracts for the turbines and generators.

7. ISWACO, in cooperation with the provinces, did an excellent job in handling the resettlement program. New towns were constructed around the periphery of the reservoir to cater to the 7,100 displaced families. ISWACO paid for the cost of site acquisition, the new public facilities and services to the new housing sites, while the residents paid for their new dwellings using the proceeds of compensation and, where necessary, loans on favorable terms from the Korea Housing Bank.

8. Project Costs. The total project cost was $602 million compared to the appraisal estimate of $510 million, an increase of 18%. Expressed in Korean Won, the total cost was W588 billion compared to the appraisal estimate of W247 billion, an increase of 138%. During implementation the Won declined from W485-US$1 to W893=US$1. The main reasons for the cost increases were a considerable overrun in resettlement costs, and construction of the relocated roads and rail track to higher standards than the facilities replaced.

9. Economic Rate of Return. At appraisal the project's ERR was estimated at 12%. In its PCR, ISWACO estimates the ERR as 13.9% after taking into account changes in cost and other factors. This is probably a reasonable approximation since there have been no other significant changes in the assumptions made at appraisal, except for an increase in the bulk water tariff which offset the cost increase.

10. Covenants. ISWACO was in compliance with the main loan covenants by completion of the project.

Performance of the Borrower and the Bank

11. ISWACO did an excellent job in procurement and contract management for all phases of the project. Of particular note was ISWACO's performance in handling the resettlement program in cooperation with the provinces, and in securing additional funds to overcome severe budget cuts in 1983 by borrowing from the Oil Surplus Fund.

12. The Bank worked closely with ISWACO in the early stages of the project to resolve some important issues in project formulation identified in the feasibility report. A proposal to include provision for future raising of the dam was dropped when it was shown that the cost would far

outweigh the benefits; in fact, the project as constructed provides virtually complete control of the river. The installed capacity was increased to 460 MW from 270 MW and the mode of reservoir operation was changed to minimize loss in peaking capability without loss in water supply benefits. The project benefited from the services of an independent consulting panel, as recommended by the Bank. Finally, the provision of financing for the engineering of the Nakdong Barrage Project, as suggested by the Bank, led to the timely execution of this project which is vital to the future water supply of the Pusan area.

PROJECT COMPLETION REPORT

KOREA

CHUNGJU MULTIPURPOSE PROJECT (LOAN 1666-KO)

1. INTRODUCTION

1.01 On 20 July 1978, the Bank approved a loan of $ 125.0 million to finance the foreign exchange cost of the Chungju Dam Multipurpose Development Project in the Republic of Korea. The Loan Agreement was signed on 29 March 1979 and the loan became effective on 1 July 1979. The Project was commissioned on schedule on the end of 1984, although some of works were not completed untill 30 June 1985. The closing date of the loan was extended from 30 June 1985 to 31 December 1985 for the landscaping and provisional civil works of contract No. 79/C/001. It was finally closed on 22 January 1986.

2. PROJECT IDENTIFICATION, PREPARATION AND APPRAISAL

A. ORIGIN

SPECIAL CIRCUMSTANCES (BACKGROUND)

2.01 POPULATION : About one third of the Korea population in 1978 resided to the Han River basin covering 26 % of Korea's land area. The lower Han River area including Seoul and Incheon accounts for about 25 % of the Korea population. The population of Seoul was 7.25 million in 1978 and the entire Han River basin was to have a population of 9.5 million. Thus, the population of Seoul would be 8.6 million in 1981 and the entire Han River basin would expect to have population of about 11.4 million.

2.02 ECONOMIC GROWTH : In the past two decades, the economy has made rapid progress in manufactural sector and in other industrial sections. The annual rate of growth in GNP per capita during the 1961-1974 period is about 9 percent. Growth of industrial output has made very rapid advances in the past five years. The index of industrial production has shown an increase of 165% from 1970 to 1975.

2.03 MUNICIPAL AND INDUSTRIAL WATER SUPPLY : As growth in the service area continues, demand for water, especially below Paldang, will increase rapidly. Should river flows become critically limited in the Seoul area due to the combination of dry periods and heavy upstream water demands, salt water intrusion from tidal movements can be a serious hazard. The projections in the Han River Basin Reconnaissance (hereinafter refered to as "HRBR") report show that M & I water demands downstream of Paldang would exceed the existing supply by the mid 1980's.
Projections based on field studies in 1976 during the preparation of feasibility report, lead to the same conclusions. It is apparent that additional major storage facilities such as the Chungju Project on the South Han River will be needed without delay, especially, when considering the time necessary for detailed planning, design and construction.

2.04 FLOOD CONTROL : About 55 % of the annual runoff concentrates only in 3 months from July to September. About 70 % of the annual precipitation occurs in four month June, July, August and September. Therefore, the Han River basin has been subjected to frequent flooding during the months of July through September.

2.05 THE POWER SECTOR : With rapidly rising industrial production, employment and GNP, there is no doubt that demands for electric power will increase at a rapid rate. Hydroelectric power resources in Korea are limited. As compared with large thermal power plants, either fossil-fueled or nuclear, hydroelectric generating facilities have the advantage of flexibility of operation, use of a renewable resources as a prime mover, and the absence of both thermal and air pollution effects. The HRBR report concluded that a hydroelectric plant at dam such as Chungju, should be designed and operated as a peaking facility to take advantage of the hydro-flexibility.

2.06 IRRIGATION : The agricultural sector in the Korean economy has made relatively slow progress in production compared with the other sectors. However, it is believed that this can be partially alleviated in the foreseeable future through improved agricultural practices. Without the Project, crops may suffer from shortage of water for proper growth under the prevailing rainfall conditions in this area. Water shortages may occur during planting, thus effecting proper seeding and the growing season, seriously decreasing the yield. Therefore, the development of irrigation will need to improve the rice production, including the existing irrigation system and the other factors related to it.

ROLE OF THE PARTIES IN THE IDENTIFICATION

2.07 THE BANK : The Bank has reviewed on the overall course of the Project (e.g. the necessity of project's development. background etc) and disscussed in details with the parties concerned to assist in financing the project. As a result of it. the Bank has prepared the Staff Appraisal Report for the purpose of analysis of the Project justification.

2.08 THE GOVERNMENT : The result of the study on the Chungju Project made by Han River Basin Survey has revealed the 1st priority followed by Soyang project and the largest potential hydropower in the Han River Basin. Thus. Chungju Project has been involved in the Dam Development Decade Program and the 3rd 5 year Economic Development Scheme by the Government.
With a aim of in corporating the above Project. the Government has made effort to support ISWACO and discuss with the Bank.

2.09 ISWACO : According to changed economy and the oil price risen internationally. ISWACO has insisted on urgent requirement of potential hydropower development in Han River basin. Thus. ISWACO has demanded assistance and cooperation for the Project to the Government.

ALTERNATIVE COMPONENTS

2.10 An alternative to upstream storage considered in the USBR study was the construction of a barrage at Hangang downstream of Seoul on the lower Han. Such a barrage would prevent salinity intrusion and hence allow some reduction in the maintenance flow requirements. USBR rejected this solution because it would be necessary to divert all municipal and industrial effluents downstream of the barrage. This alternative was considered during appraisal. In addition to the objection noted by USBR it was found that even if the maintenance flow were reduced by 60 % in the six-month dry season (a total volume of 900 MCM) it would defer the need for upstream storage for only about five years. Thus. it was concluded that the Hangang Barrage was inferior to upstream storage in meeting the water needs of the Han Basin.

2.11 Other than Chungju. the only large undeveloped reservoir site in the Han Basin is on the Hongcheon River. a tributary of North Han. The dam would provide complete regulation of an annual runoff of some 1,000 MCM. Constructed by 1985. Hongcheon would meet incremental downstream water demands through 1992. The project would have an installed capacity of 100 MW and generate about 140 GWh in an average year. Flood control benefits would be negligible. This project was chosen as the first in the sequence of projects forming an alternative to Chungju. There are three possible projects to be considered for construction to meet demands after Hongcheon. These are Yeoju on the South Han. and Dalcheon and Kanhyon both on tributaries of the South Han. In the case of the latter two. the annual runoff is only about 1,000 MCM and would not be fully regulated because at both sites the topography limits the reservoir capacity to about 700 MCM. At Yeoju. the

storage capacity is only 800 MCM. but the upstream catchment area is very large and annual runoff is of the order of 7.300 MCM. The useful yield of Yeoju would be greater than the other two reservoirs and would meet downstream incremental demands for a longer period. Yeoju has therefore been chosen as the next project in the alternative sequence to be in service by 1991. The head available for power generation would be only about 20 m. and the installed capacity would be about 100 MW and annual energy generation some 200 GWh.

2.12 The feasibility study by ECI revealed that the Chungju Project with a dam constructed to a height of El. 176.0 m would result in the maximum net benefit. However. giving due consideration on social problems to be involved owing to the inundation of greater scale including the Seong Sin cement plant as well as an avoiding extremely high initial cost of the project. ECI recommended two stages development. consisting of the first stage of the dam constructed to a crest level El. 150.5 m and power installed capacity of 210 MW and the second stage of the full scale completion.

2.13 However. a dam of lower crest elevation. i.e. El. 150.5 m. it involved the problem of inundation of various properties including the Seong Sin cement plant. Therefore. plans with further lowered crest elevation have been taken up for consideration. The selected dam crest levels for comparative study are El.150.5 m. El.147.5 m and El.145.5 m.
As a result of various trial. reservoir operation studies to estimate the combined benefits of water supply. power generation and flood control in accordance with the above dam height. the dam with the crest elevation of 147.5 m is finally recommended as most desirable in producing the biggest net benefit.

EFFECTIVENESS OF THE FEASIBILITY STUDY

2.14 ECI has executed the feasibility study to review the vast body of existing information of the Han River basin and to verify the priority of the Chungju Project and to determine the scope of the Chungju Project in relation with the other projects along the Han River. Besides. ECI has implemented in technical. economic and financial feasibility study of the Project.
It described the result of the study on the most economic alternative proving that the construction of the Chungju multipurpose dam project has first priority in the present situation when compared with other alternative schemes on the Han River basin and the optimization of the selected scheme in regard its proposed water uses. Thus. the feasibility study of the above were very useful in the course of choice of the project.

B. PREPARATION. APPRAISAL. NEGOTIATION AND APPROVAL

PREPARATION

2.15 ISWACO : For the purpose of developing the large untapped hydroelectric potential of the Han River Basin. ISWACO. together with the Government. has made an effort to assist actively the Han River Basin Survey carried out by the United States Breau of Reclamation. This survey began in 1966 and was completed in 1971. An important finding of this survey was that additional storage would be needed in the basin by 1986 and this requirement would be best satisfied by construction of the Chungju dam. ISWACO also has executed the prefeasibility study from 1968 to 1971 by itself. Thus. ISWACO. together with ECI. has implemented the feasibility study to review the result mentioned above and to verify the priority of the Chungju Project and to determine the scope of the Chungju Project and to analysis technical. economic and financial feasibility of the Project.

2.16 THE CONSULTANTS : The consultants has prepared the following parts :

- Review of ECI's Feasibility Report and preperation of Preliminary Design Report (e.g. Review of design flood. Review of dam site geology. Review of arrangement of structures. Design check of proposed structure. Alternative study on dam height. Capacity of power generation. Reregulation dam. Preliminary cost estimates. Construction equipment and plant planning)
- Geological and material investigation (e.g. Assistance to geological investigation by ISWACO. Geology of reservoir area. Evaluation of landslide possibility. Reservoir induced earthquakes. Rock test)
- Preparation of specification design (e.g. Specification design of construction plant foundation. Specification design of diversion works. Specification design)
- Preparation of tender documents
- Preparation of engineer's cost estimates.
- Preparation of design report.
- Assistance to ISWACO in contract arrangement.
- Preparation of manuals and specification.
- Overseas training arrangement.

2.17 THE BANK : The bank's involvements in the preperation process were summarized as follows:

- The matters on the constitution of the consulting panel.
- The matters on the selection of the project consultants.
- The matters on the decision of the dam crest.
- The matters on the increase of the generating capacity.
- The matters on the executing agency of the project.
- The problem on the compensation of submergible area.

CHANGES

2.18 HEIGHT OF DAM : Lowering the height of dam by three meters to ease the problem of protecting the cement plant from inundation and the cost of construction.

2.19 THE INSTALLED CAPACITY : In appraisal stage the Bank recommended an increase in powerplant capacity from 210 MW (3 units of 70 MW each) to 460 MW (4 units of 115 MW each) in order to produce the highest net benefit at peek time. Reviewing the study by ECI, the consultant recommended that the power installation larger than 210 MW as proposed by ECI, should be taken into consideration against the prospect of the peak demand growth toward 1980's. The cost comperative study carried out for gas turbine, pumpedstorage, combined cycle and hydropower such as Chungju, showed that Chungju would be the cheapest at the plant factor of about 10% with installed capacity of 400MW. Consequently, the installed power capacity for the project at final stage was determined 400 MW (4 units of 100 MW each).

2.20 THE LOCATION OF THE POWER HOUSE : The location of the power house was changed on the right bank instead of the left bank as proposed by ECI because of mentioned below:

- Cost increase due to the necessities of steel lining of deversion tunnel in the portion to be used as headrace and provision of main valves.
- Serious delay of the Project completion owing to a large amount of works including penstock installation required after the closure of diversion tunnel.
- Problems to power generation by including a high surge and producing a pile over the tailbay, etc.

2.21 The above changes presented by ISWACO was reviewed by the Bank. The Bank in accordance with the result of the review readily agreed on these changes. The above changes were very beneficial, in retrospect.

BANK'S INSISTANCE COVENANTS

2.22 The Bank's insistance covenants were as follows :

- The bank insisted that ISWACO instead of the Government would be appointed as the representatives of executing agency for the Project, necessarily.
- The Bank recommended that ISWACO should employ a consulting panel as advisors in reviewing and approving designs prepared by the consultants for the Project.

2.23 ISWACO had no objection to organizing a consulting panel and being the executing agency, it is found that these covenants proposed by the Bank has contributed to improve ISWACO's technical and constructing capacity and to assist in reviewing and approving designs prepared by the consultants, in restrospect.

2.24 Generally, project preparation was carried out expediently. There were not any unusual delays between identification and effectiveness.

APPOINTMENT OF CONSULTANTS

2.25 The Bank emphasized the need for early selection and appointment of a consulting firm in order to implement the Project early, subjected to the proposed construction schedule. Consulting services for the Project design and supervision was financed by OECF. In December 1977, ISWACO invited proposal for design and construction from four Japanese firms, were prequalified to bid for the detailed investigation, design and supervision of the Project. In the course of sellection of the consulting firm, ISWACO and government were sent several times to the Bank in order to review and comment about the status of consulting services concerned. Also, ISWACO applied for the Bank's approval about the results on the final evaluation of the proposals. Consequently, only two firms were selected as the qualified tenderer among applicants who submitted their prequalification and tender documents except one firm in reason of period shortage. The contract under the Bank's approval was awarded to the most qualified bider, NIPPON KOEI Co., a Japanese firm, in association with Samen Engineering of Korea was selected in March 1978 and contract was signed in May 1978. NIPPON KOEI has wide experiance in the engeering of major hydroelectric projects in Korea and elsewhere. The value of the contract was Yen 1,489 million of Japnese Yen portion and ₩ 985 million of Korean Won portion, respectively.
The consulting services was commenced on 18 May 1978 and finished on 3 Octover 1985. The consultants, whose terms and conditions of employment have been reviewed by the Bank, will provide the following services :

- Detailed design and preparation of contract documents for the dam, spillway and power house ;
- Preparation of contract documents for mechanical and electrical equipment ;
- Assistance to ISWACO in advertisement of bids, prequalification of bidders, evaluation of bids and award of contracts for civil works and equipment ;
- Supervision of civil construction, inspection of equipment fabrication, and supervision of equipment installation and performance tests ;
- Review and certification of peyment requests submitted by civil works contractors and equipment suppliers ;
- Preparation of monthly and annual progress reports ; and
- Assistance to ISWACO in the initial operation of the project and in establishing operation and maintenance procedures.

In the course of the detailed design and construction supervision for the Project, the consultants carried out the services very well.

C. TARGETS AND GOALS

2.26 The drainage basins of Korea's four largest river, the Han, Nakdong, Geum and Yong san, account for nearly two-thirds of Korea's land area. Because of Korea's mountainous terrain, most of its major cities and industrials as well as much of its best agricultural land lie along these major rivers and depend on them for their water. Korea has the advantage that an unusually high proportion of its annual precipitation, nearly 50 % appears as surface water runoff. However, this advantage is offset by Korea's high population density of about 350/sq km with the result that annual surface water runoff per capita is about 2.100 cu m compared to 4.300 cu m for Japan and 13.100 cu m for the U.S.A.

2.27 In the 1960's it became apperent that water demands for city, industries and farms would soon exceed the unregulated flow in the dry season (November through March) when only 15 % of the annual runoff occurs. Also, with the rapid urban and industrial development, and the more intensive cultivation of the farmlands, the consequences of floods had become much more serious during the three months - July, August and September - when the rivers carry 60 % of the annual runoff.

2.28 Recognizing also the large untapped hydroelectric potential of these river basins, as a result of the above, the government commissioned the preparation of multipurpose development plans for each of Korea's four major river basins. Besides, the government plan concerning long-term development program was included in the Dam Development Decade Program and in the 3rd 5 year Economic Development Plan. The Chungju Project also was included in this plan.

2.29 The Government and ISWACO reviewing in the overall scheme mentioned above, has determined the construction of the Chungju project having the 1st priority in the situation when compared with other alternative schemes and the largest potential hydropower in the Han river basin.

D. PROJECT DESCRIPTION

2.30 The principal features of the proposed Chungju Multipurpose project are summarized below :

- Construction of a 90 m high concrete dam on the South Han River ;
- Construction of a powerhouse below the dam on the right bank of the river ;

- Supply and installation of four 115 MW generating units and appurtenant and electrical equipment ;
- Supply and erection of a 10 km long, 154 kV double-circuit transmission line ;
- Construction of a reregulation dam about 20 km downstream of the main dam;
- Relocation of about 100 km of roads and 10 km of railway ;
- Construction of protective works in the reservoir area including the raising of an existing flood embankment at a cement plant, and miscellaneous works to ensure continued operation of a talc mine ;
- Implementation of a reservoir resettlement program including compensation of some 9.300 families for land and property, and assistance in their resettlement ;
- Consulting services for detailed design and construction supervision of the project ;
- The services of an independent consulting panel to assist ISWACO in their review and approval of the consultants' designs ; and
- Consulting services for detailed engineering of the Nakdong Barrage Project, the next phase in the development of the Nakdong River Basin.

2.31 MAIN DAM AND SPILLWAY : The concrete gravity dam would have a maximum height above streambed of about 90 m and a crest length of 450 m. The upstream face would be vertical and the downstream face would have a slope of 0.75 to 1. The spillway would have five 22 m high radial gates with a span of 15 m. A stilling basin at the toe of the dam would dissipate the energy of the spillway discharge. The dam would contain about 900.000 cu m of concreate. A 7 m wide service bridge would be provided along the top of the dam. The only unusual feature the dam will be the excavation of some 5 million cu m of slide material on the right abutment.

2.32 DIVERSION TUNNELS AND COFFERDAMS : A flood with a 25-year return period is generally adopted for the design of river diversion works during construction. The 25-year flood for the wet season (July-September) is 10.500 cu m/s, and for the dry season (October-June) is 3.500 cu m/sec.
In the proposed diversion scheme, a concrete cofferdam would be built upstream and rockfill cofferdam downstream of the damsite. The downstream cofferdam would be armored with large rocks and heavy cable mesh to withstand overflow in the wet season. The dry season flow would be diverted through two 12 m diameter, concrete-lined, diversion tunnels each about 500 m in length. It would be too costly to provide for diversion of the wet-season flood since it would require additional tunnels and higher cofferdams. Therefore, during wet seasons following completion of the tunnels, the cofferdams would be overtopped and the river allowed to flow through the dam site.

2.33 POWER FACILITIES : The power plant would be located at the toe of the dam on the right bank. Individual penstocks, each 6 m diameter, would connect the generating units to the power intakes in the dam. The powerhouse would be equipped with four 115 MW generating units. The switchyard would be about 1.000 m from the powerhouse and would be linked to it by one single - circuit and one double-circuit 154 kV tansmission line. A 10-km long 154 kV double circuit line will link the switchyard to the main grid at the Chungju

substation.

2.34 ROAD AND RAILROAD RELOCATION : Sections of two highways totalling 100 km. including bridges with a total length of 1,600 m. would require relocation in the reservoir area. The railroad connecting Seoul to Busan passes through the reservoir area. About 10 km of track would have to be relocated, including eight tunnels with a total length of 930 m and eleven bridges with a total length of 500 m. Also a new 400 m span rail bridge across the South Han would be needed.

2.35 PROTECTIVE WORKS IN RESERVOIR : An existing flood protection dike surrounding the Sung Sin cement plant would be raised by 1 m to El. 146 m. This would protect the plant during short periods when the reservoir level rises above its normal of El. 140.5 m for flood control. Works at the Dongyang Talc mine would include sealing of an entrance to the mine at El. 137 m and two disused entrances at El. 142 m and El.144 m. A new entrance would be opened at El. 168 m. A retaining wall about 20 m high and 130 m long would be built to retain the tailings from the mine and prevent the mine wasters from polluting the reservoir.

2.36 REREGULATION DAM : During the dry season the outflow from the Chungju reservoir will be released through the powerplant for two or three hours each day. Thus, without provision for reregulation of these releases, there would be wide fluctuations in the flow of the South Han. These changes in flow would cause wide variations in water levels and cause operating difficulties at the numerous intakes for irrigation, municipal and industrial water along the river. The reregulation dam is located 20 km downstream of the Chungju Dam and with a storage capacity of 8 MCM, it would store the daily inflow and release a uniform flow to the river. The dam would consist of a gate-controlled concrete weir about 340 m long with a crest at El. 58.0 m, some 8 m above its bedrock foundation. It would have twenty, 15 m wide bays, three of which would be controlled by 5 m high radial gates. These gates will control outflow in the dry season when the other bays would be closed by stoplogs. Reregulation of powerplant releases would be unnecessary during the wet season and the stoplogs would be raised to permit passage of flood flows.

3. IMPLEMENTATION

A. EFFECTIVENESS AND START-UP

3.01 The Loan Agreement was signed on 29 March 1979 and was declared effective on 1 July 1979. that is. after a period of 92 days almost same as 90 days specified in the loan documents. There was no special problems and delays in start - up period. The works on access road and site prereration for the Project were undertaken by the ISWACO during this period utilizing its local funds.

B. REVISIONS

IMPORTANT CHANGES

3.02 SPILLWAY SIZE : Originally. in tender design stage. the spillway was have 5 bays with 15 m span each. El.123 m overflow crest. 4 m thick piers and total width of 91 m. The 91 m wide spillway results in unit discharge of 170 cu m/s/m for the design flood (16.000 cu m/s) and 230 cu m/s/m for the PMF outflow. Because such high unit discharges exceed those of satisfactory performance records available from other projects. The item mentioned above was pointed out by IBRD'S consulting panel in May 1979. Thus. ISWACO finally determined te widen the spillway from 5 bays to 6 bays each having 15.5 m wide and overflow crest elevation of El 126.0 m. Thickness of intermediate piers was determined to be 3.5 m so as to surely support gate load and withstand lateral water pressure. Total width of spillway is 110.5 m including piers. This spillway size satisfies the discharge capacity requirement of 16.000 cu m/s at the reservoir water level of El 145.0 m. Thus. unit discharge of the 6-bays spillway is 145 cu m/s/m for the design flood and 185 cu m/s/m for the PMF.

3.03 THE REREGULATION DAM : In the course of formulating the reregulation dam scheme. a feasibility of the power generation at the reregulation dam site was investigated in 1978. However. the result was negative at that time. although it suggested to become feasible depending upon the future oil price trend. Since 1978 to the beginning of 1981. the oil price has radically jumped up higher than 3 times and consequently the situation in 1978 was changed very much. Thus. based on above investigation result. the feasibility study of the power generation at the reregulation dam was

conducted in the light of the latest available information in the earlier part of 1981. As a result of optimization study on power installation at reregulation dam. the optimum capacity of power generation with the minimum cost was determined 12 MW comprising two units of 6 MW plants.
Besides mentioned above. reservoir H.W.L and L.W.L was El. 62.0 m and 58.0 m respectively. in the early stage of appraisal. However. taking into consideration the installation of the power plant at the reregulation dam. optimum development was found to be H.W.L of 66.1 m and L.W.L of 65.0 m respectively. in reviewing the report by the consultant. Taking into consideration the social impact of inundation areas in the final stage of design. the development scheme was determined H.W.L of 65.1 m and L.W.L of 63.5 m respectively by lowering the H.W.L by 1.0 meter.

3.04 DISBURSEMENT RATE OF THE LOAN : Local financing budget for the civil works scheduled in 1980 is so limited that originally planned completion date(1985) should be delayed for one year at least. In case of above delay. looking management of ISWACO. assessment of all of the revenues expected to be made after the project completion will also be delayed and will be acted as a worse factor in repayment of the Bank's loan commencing ctober. 1983.
Thus. the deficit for the civil cost is requested to the government. However. according to worsened international economic situations due to rapidly increased oil price and the government's retrenchment policy to control the inflation. it is hardly expected to get a supplementary budget.
Therefore. ISWACO has required early withdrewal of proceeds of the Bank's loan for smooth implementation of civil works as scheduled. in purpose of ensuring the deficit from the limited budget in 1980. In relative to ISWACO's request. the Bank was agreeable to amending the loan agreement by changing the figure in the "of expenditures to be financed " column in category I(b) of paragraph I of the Loan Agreement to be 65 % in place of 45 % after detail review.

3.05 COMPENSATION : In appraisal stage. compensation scope for land and property as comparison with the previous project constructed in Korea was determined. Actually. as a result of site investigation during two years (1979-1980). compensation scope for land and property was expanded. With realization for compensation unit price and the increase of the inundation area according to installing the power plant at the Reregulation Dam. the compensation scope of the project was increased very much.

3.06 THE RESETTLEMENT SITES : In the appraisal stage. the executing authorities would make plan to pay removal expenses and subsistence. and to give the priority for purchase of reclaimed tidal land executed by the government including land in Yong San Gang cultivation project to persons displaced by this Project. But the resettlement sites requested by the displaced persons in the early construction stage which was constructed at Danyang. Cheongpung and Hansu including seven groups camp. With resettlement sites for the displaced persons. the scope of the overall compensation was largely changed.

3.07 ROAD RELOCATION : Road relocation with a total length 100 km having bridge with a total length 1,600 m was proposed at the appraisal stage. In the course of finalizing the detail design, road relocation with a total length 297.3 km having nineteen bridges with a total length 2,728 m was determined.

3.08 RAILROAD RELOCATION : Railroad relocation with a total length 10 Km having eight tunnels with a total length 930 m and eleven bridges with a total length 500 m was proposed at the appraisal stage of the project.
In the course of the detail design, railroad relocation with a total length of 13 km including three tunnels with a total length of 1,810 m and six bridges with a total length of 850 m was determined.

REJECT OF THE BANK

3.09 ISWACO received the information from the Bank with regard to disbursement rate for the civil works be reverted to 45 % from 65 %, and reviewed it. The result of above means the deficit of budget in 1982. If ISWACO revise overall Project schedule, the completion date should be delayed for one year at least, it will be acted as a worse factor in repayment of the Bank's loan and in the management of ISWACO. Thus, ISWACO has requested to understand difficult situation and to keep 65 percent of disbursement rate for the civil works by end of that fiscal year. In addition to it, ISWACO has expected to be postponded the grace period of Bank's loan for two or three years for smooth repayment with power charge collection. With respect to the above, the Bank informed ISWACO that it is found that firstly the ISWACO's propose to postpone the initial repayment date by extending the grace period would require a change in the basic terms of the loan. Because it has been a long standing Bank policy to retain loan items intact. The Bank didn't accede to this proposal.

3.10 Secondly, with respect to the request for the review of its disbursement rate on the civil works, the Bank informed that this has been unusual for Bank-assisted project in Korea, which has achieved over the years an enviable record of carrying out projects on schedule. In June, 1980 the Bank concurred in an increase in the disbursement rate on this Project because of above reason. This increase, which the Bank always regarded as temporary, recognized the financial constraints the government was confronting in mid-1980 due to a number of factors including rapid price escalation. The step was quite unusual since the Bank's loan amount is fixed and when project costs escalate. The Bank normally decrease rather than increase its disbursement rate. The Bank had expected that by covering a very high proportion of project expenditures during this prior of budgetary stringency, the government would increase its funding significantly in future years. Unfortunately, while budget allocations were increased somewhat in 1982, the amounts allocated were, even in nominal terms, only slightly above 1981 budget allocations. In the course of reviewing it, it was concluded that ISWACO have not received the priority in the allocation of budgetary fund the Bank had expected when the Bank contracted the loan.

Therefore, the Bank would not be able to continue in such manner post the end of 1981 on any project where it would result in exhaustion of Bank funds before project completion. The Bank recommended that, returning to the original disbursement percentage of the Bank, the government must seek other means to overcome the problem caused by budget stringency.
After IBRD's information, with borrowing from the oil Fund parties made on effort to overcome the problem of slow execution of the project without delay of the overall schedule.

REALLOCATION OF THE LOAN

3.11 As a result of a discussion with MOF's and ISWACO's staffs during their staying in Washington D.C about increasing percentage of loan portion of category 1. civil works due to budgetary constraint of government during a period of rapid price escalation, the BANK agreed to amend the Loan Agreement to increase bank's portion of civil works from 45 % to 65 % as a temporary measure in consideration of government's budget situation in 1980 and hoped the government would assist ISWACO by larger local fund allocation in 1981 and 1982 in order not to cause delay in reservior impounding and Project operation. Bank notified ISWACO that disbursement percentage for category 1. would revert to original percentage of 45 % from Feburuay 11, 1982 because Bank thought continuity disbersement of 65 % would lead to being used up of loan proceeds before completion of project. On March 19, 1982 MOF asked to the Bank to have second thought about exchange in the disbursement percentage from 65 % to 45 % for the shortage of government budget and requested that bank maintain 65 % withdrawal percentage untill end of 1982 and grace period be extented 2.5 years untill construction is completed. On April 6, 1982 the Bank disagreed to above proposal for the reason of Bank's long standing policy to retain loan terms intact and hoped the government more budget would allocated to the Project. ISWACO proposed through MOF reallocation of the loan proceeds twice on April 23,1984 and March 22,1985 respectively as shown in the Appendix 6 and once extention of closing date from June 30, 1985 to Dec. 31, 1985. Each time BANK agreed to ISWACO's proposal. The disbursement was completed on January 22, 1986 and the remaining undisbursed balance of US $ 1,810,842.38 was cancelled by ISWACO reqest.

IMPLEMENTATION OF COVENANTS

3.12 THE POWER TARIFF : A cost allocation study has been completed and a copy of the results was given to the Bank. Negotiation with KEPCO and other beneficiaries of the project about the rates will be charged to them by ISWACO. The detail status of the power tariff negotiation with KEPCO shall be described in the other paragraph.

3.13 THE DRAW-DOWN ZONE : The land in the draw-down zone in the reservoir has been acquired by the provinces but will be available for a early season crop. Most of the former owners of these land continue to live close to the reservoir. Therefore, the provincial authorities make a plan to rent the

cultivation rights annually to the original owners for a fee equal to 30 % of the value of production but not yet be settled.

3.14 O & M MANUAL : The Report on Operation and Maintenance Manual (including the Report on Reservoir Operation Rule for Production of Maximum Output) which was made by the consultant, N.K. was submitted to the Bank, May.Dec 1985 in accordance with section 4.04 of article 4, the Loan Agreements.

3.15 THE AUDIT OF PROJECT ACCOUNTS : According to the Loan Agreement (section 5.02), ISWACO has maintained seperable accounts for the Project and employed independent auditor, accepted by the Bank, to audit the Project accounts annually. The report of audit, including certified copies of financial statements audited was sent to the Bank within four month of the close of each financial year.

C. IMPLEMENTATION

IMPLEMENTATION

3.16 At appraisal stage, the project made a plan to be implemented over a period of six years, including one year of preconstruction activities. Construction would begin shortly after the award of the main civil works contract. The construction of the dam, including installation of spillway gates, would be completed by the end of 1984. By changed due to detailed design and further study reflecting economic situations at early construction stage, main revisions have been made in dam height and its reservoir capacity, installed power capacity and number of units, and additional power station to be installed at reregulating dam. In addition to the above changes of the Project features, the Project period was delayed for one year by various unavoidable reasons as below :

- Delayed commencement of Main civil works : Main civil works which are being financed by IBRD was scheduled to be commenced in September, 1978. However, Loan Agreement with IBRD was made on 29 March, 1979 and consequently the commencement of main civil works for dam and powerhouse was delayed for 16 months by starting the works on January, 1980.
- Project delay due to increase of project costs : Because of worsened international economic situation and realization of compensation price and the increase of inundation area in accordance with installing the power plant at the Reregulating dam.

The Project costs has been largely increased due to the bigger ratio than expected. As for above, the overall construction schedule of the project was delayed for one year. Consequently, excluding delayed commencement of main civil works, total construction period was 6 years until the work

has completed on schedule in late 1985 sucessfully. The comparison of the actual and original schedule descrived in appraisal report shown as Appendix 4. In summary, the original time schedule described in the appraisal report was realistic.

COMPLETED PROJECT DESCRIPTION

3.17 The principal features of completed Chungju Multipurpose Dam Project are summerized below and illustrated in Appendix 2 and 3. Also, the salient features of the Project presented in Appendix 5.

- Construction of a 97.5 m high and 902,000 cu m of concrete gravity dam on the South Han River ;
- Construction of a powerhouse below the dam on the right bank of the river ;
- Supply and installation of four 100 MW units and appurtenant mechanical and electrical equipments ;
- Supply and election of a 7 Km long, 154 kV double - circuit transmission line ;
- Construction of a Reregulation dam about 20 Km downstream of the main dam ;
- Relocation of about 297.3 Km roads and 13 Km of railroad ;
- Construction of protective dam in the reservoir area to ensure continued operation of the Dongyang Talc mine ;
- Implementation of the resettlement program including compensation 7,105 families for land and property, and assistance in their resettlement ;
- Consulting services for detailed design and supervision of the Project construction ;
- The services of an independent consulting panel to assist ISWACO in their review and approval of the consultant's design ;

3.18 THE TREATMENT OF LANDSLIDE : The landslide treatment on the right bank of the dam site was one of the most crucial works in Project implementation. In 1976, ENGINEERING CONSULTANTS INC., which undertook the feasibility study of Chungju Project, was aware of existence of landslide on right bank. But, an extent of the landslide was not made clear at that time. In 1978 and 1979, NIPPON KOEI(NK) and ISWACO in accordance with the Bank's recommendation carried out intensive field investigations to define the extent of landslide and to assess the dam foundation. The investigation included field reconnaissances by landslide specialists and geologists, seismic wave exploration, test adits excavation, core boring and rock sheer tests. In addition, in the course of determining the landslide extent and the method of landslide treatment, valuable suggestions and recommendations were given by the IBRD's Consulting Panel especially Mr.J.S.Dodd (engineering geologist) to ISWACO and NK. The upslope extent of landslide was defined by interpreting the boring logs obtained in upper part of hill between El. 350 m and El. 450 m. It was concluded that the landslide extent up to El.400 m. The slide mass was predicted to thicken towards uphill, 0 m at river shore, 25 m at dam crest

level and 40 m at elevation of 300 m. The predicted failure plane having dip angle of 20 degree to 30 degree or 23 degree in average was subparelled to original ground surface. The landslide was classified into two different types of slide ; rock slide and slump. Thus, the method with entire removal of rock slide was selected in view of paremount importance of the safety for dam and power station to be located below the slide area. The slump material upstream of rock slide area was to be left unexcavated for cost saving. To stabilize the slump, toe loading with excavated rock material was considered most effective. Therefore, the toe embankment area was selected as mandatory disposal area. Required volume of the toe embankment was approximately 2 million cu m. Excavation work of rock slide material on right abutment commenced in May, 1980 and continued for 23 months until it was completed on March, 1982. Total excavation volume amounted to 5.538.000 cu m.

3.19 MAIN DAM AND SPILLWAY : The Chungju Dam is a 97.5 m high and 447 m long concrete gravity dam having its crest level of El. 147.5 m and creating a 2.750 million cu m reservoir. The upstream face is vertical above El. 114.5 m and has slopes of 1 on 0.17 between El. 114.5 m and El. 84.5 m and of 1 on 0.3 below El. 84.5 m. The downstream face has single slope of 1 on 0.75. The spillway has six span of 15.5 m. A stilling basin at the toe of the dam would dissipate the energy of the spillway discharge. A 8.5 m wide service bridge is provided along the top of the Dam. Dam foundation excavation was commenced early March, 1981 at top portion of left abutment on which bunker line be constructed and completed in March, 1982 excavated volume was approximately 990.000 cu m in total. Concrete placement of dam and spillway was commenced in June, 1981 and finalized on October 27, 1984 just before the scheduled impounding date of Nomvember 1, 1984. Finally total dam concrete volume is about 902.000 cu m including penstock encasement.

3.20 DIVERSION TUNNELS AND COFFERDAMS : Selected design flood for river diversion scheme is 3.000 cu m/s. This flood corresponds to peak discharge of the dry season flood (April flood) having occurrence probablity of 5 % (once in 20 years). In addition, a 25-year probable wet season flood (10.500 cu m/s) was taken into consideration in scheduling the concrete placement for main dam and designing the cofferdams, diversion tunnels and other important construction facilities. The tunnel capacity is governed by reservoir pool level ponded during flood. Higher cofferdam requires smaller diversion tunnel. As a result, two 12 m diameter concrete-lined circular tunnels about 626 m, 701 m each in length satisfied this requirement. The combitionation of the twe 12 m diameter tunnels and El.85.5 m cofferdam was finally adopted for construction. The tunnel elevation was set to El. 65 m at upstream end and to El. 63 m at downstream end in its bottom level. The upstream bottom level is nearly equal to the river channel bottom level. The downstream bottom level is a few meters lower then the river channel. Complete circular section of the tunnel adopted in tender design was modified to bottom-flat circular section at the final construction design in order to facilitate concrete placing in tunnel invert. Length of plug concrete required in respect of sliding due to reservoir water pressure is 16.5 m. This length is elongated for allowance to prevent piping in surrounding rock.

For construction of tunnel lining, a 40 m long plug was adopted. The length is equivalent to 50 % of maximum active water head operation of dam.
The plug length was further reviewed shortly before the diversion closure because the rock surrounding the plug portion encountered during tunnel excavation was quite massive not containing predominant rock joints and seams. Such good geology needed less allowance for resisting against piping.
Finally, the plug concrete length was shortened to 25 m which corresponds to 30 % of the maximum active water head. This shortening contributed to reduce concrete volume and to speed up the concrete placing which had to be completed before freezing water. Diversion of the river was carried out on October 7, 1981. The tunnels was closed by inlet gates on November 1, 1984 for permanent impounding of the reservoir.

3.21 POWER FACILITIES : The powerhouse is located on right bank 130 m downstream from the dam axis. The power station is composed of powerhouse, tailbay and outdoor switchyard. Generating capacity of the Chungju power station No.1 is 400 MW comprising four units of 100 MW plants. The power station is designed as peak load station linked with the nation-wide power grid of the Korea Electric Power Coporation (KEPCO). The enviseged peaking hour is 2.8 hrs a day and plant factor is approximately 10 %. Annual energy output of the power station is 765 GWh in average. The powerhouse building is conventional reinforced concreate structure built on sound Rock.
The building is approximately 109 m long, 44 m wide and 51 m high above its bottom El. 51.5 m. Penstock diameter is determined to be 6.5 m which is most advantageous in combined cost for penstock, intake and generator.
Removable trashrack is installed at entrance of each intake it is divided into two by the center pier. Their clear span is 6.5 m each and height is 14 m to close and dewater the water passage temporarily for repairing intake gate and its guide frame. stoplog slot is provided between the trashrack and gate at location just upstream of dam axis. The slot is also divided into two by center pier and extended up to the top of dam one set of stoplog consisting of 4 panels (two panels for each divided slot) is provided to close any one of 4 intakes. Each panel is 15.1 m wide by 4.0 m high. Intake gate is provided for each intake between intake bell-mouth and steel penstock at 11.5 m downstream of dam axis, and the gate is 6.5 m wide and 6.5 m high. The gate is operated with independent hoist installed at El. 153.3 m.
Outdoor switchyard is located between the power house building and the dam on El. 83.5 m ground level. Size of the switchyard is approximately 120 m long by 60 m wide including transformer decks. The switchyard is comprised of 154 kV switchyard for powerstation No.1 and 66 kV yard for receiving the power from power station No.2 which necessary steel towers are 32 in numbers.

3.22 ROAD AND RAIL RELOCATION : Road relocation with total length of 297.3 Km because of the load inundated by the construction of Chungju Project was relocated. The number of 17 roads relocated National roads. Provincial roads including Country roads. The road relocation was commenced on June 3, 1982 and completed on June, 1985, sucessfully. Railroad relocation with a total length 13 km was relocated and its length was included three tunnels with a total length of 1,810 m and six bridges with a total length of 850 m. The

railroad relocation was started in December 4, 1982 and finalized in December 30, 1985.

3.23 PROTECTIVE WORKS IN RESERVOIR : In order to protect the DongYang Talc mine from innundation by the construction of the Project was constructed the water retaining dam having 185 m crest length and 36.5 m height with El. 146.0 m. The water retaining dam of Dongyang Talc mine constructed for the purpose of retaining the tailings from the mine and preventing the mine wastes from polluting the reservoir was commenced on December 29, 1983 and completed on December 31, 1984. In the other hand this report is not included with regard to the Sung Sin cement plant because the protective countermeasure for cement plant was done by the owner of plant with private cost.
About 4 Km downstream of the main dam, existing Yongkyo irrigation pumping station located. After completion of the dam which would release cold water. When this cold water irrigate to a paddy land, it would be decreasing the agricultural production. Therefore, in order to prevent the cold water demage for the crop, a pond having large surface area with shallow depth for the purpose of warming the cold water was constructed and also the pumping station was relocated. This protective countmeasure was commenced on 29 October 1985 and completed on 30 June 1986.

3.24 REREGULATION DAM : The Reregulation dam is a 19 m high and 480.0 m long concrete gravity dam having its crest level of El. 70.0 m and creating a 29.2 million cu m reservoir. The river diversion scheme is selected a combination of Slurry Trench cutoff and cellular cofferdam reducing the expensive steel sheet piles and facilitating the installation and removal of the cofferdam.
The spillway structure consists of gated - overflow weir, apron for flood spillway and stilling basin for service spillway. The weir is a concrete structure founded on rock at El. 49.0 m for service spillway and El. 51.0 m for flood spillway. The overflow area is divided into 2 bays for service spillway and 18 bays for flood spillway and each bay is provided with 15 m wide and 7.7 m high roller gates. The gate hoists are installed on the hoist decks at El. 81.0 m. monorail hoist is provided for operating stoplogs.
The crest shape of the weir is determined the under nappe shape(profile) using the method of US Bureau of Reclamation. Power station with generating capacity of 12.000 kw comprising two units 6.000 kw unit is located on the left bank and consisted of intake, powerhouse and tailrace. The generating power is transmitted to power station No. 1 through the 66 kV transmission line.
The commencement ceremony of construction of R/R Dam was held on September 9, 1982. Since, the Project took 2 years and 10 months by the time of the completion ceremony held on September 2, 1985. Annual energy output of the power station No. 2 is 79.5 million KWh in average.

D. PROCUREMENT

3.25 CIVIL WORK CONTRACTS : The Project involved three civil work contracts which were awarded by International Competitive Bidding in following the Bank's guidelines on procurement mentioned below :

- Civil works for Chungju dam and power station No.1 including installation of gates & penstocks (79/C/001).
- Civil works for Reregulation dam and power station No.2 including metal works for gates (82/C/002).
- Civil works for Jungang railroad line (Dodam - Jugnyeong) relocation (82/R/001).

Six firms including one foreign firm were prequalified to bid for the construction of the Main dam and No. 1 power house. However, only four firms were selected as the qualified tenderer among applicants who submmited their prequalification documents and submitted their tender documents except a foreign firm. The contract was awarded to the lowest bidder, Hyundai Construction Co., on 18 December 1979. The value of this contract was ₩ 73.522 million (US $ 82.4 million equivalent) excluding value added tax. Besides, five firms from local firms were prequalified to bid for the construction of the Reregulation dam and No.2 power house. Three of them submitted the alternative tender, which was reviewed by the ISWACO. Thus, the contract was awarded to the lowest bidder, Hyundai Construction Co., as accept of alternative tenderer on 28 August 1982. The value of this contract was ₩ 10.936 million (US $ 12.25 million equivalent) excluding value added tax. The contractor started the construction of the dam and power house No.1 on 20 December 1979. The firm was able to complete the works on schedule under various difficult circumstances such as flood overtopping in late August 1982 and the total construction period of Main dam and power house No.1 took 6 years by the time of the completion. The construction of the Reregulation dam and power house No.2 was commenced on 9 September 1982. The contractor was able to carry out the works on schedule by recovering the difficult conditions such as a flood about 5,800 cu m/s on 2 September 1984 and the construction period took 3 years until it was completed on 30 September 1985. The relocation of Jungang railroad line (Dodam - Jugnyeong) carried out by the Railroad Construction Bureau, Korea National Railroad. In the course of the construction, the contractor carrid out the works smoothly.

3.26 EQUIPMENT CONTRACTS : There were made several contracts for generating facilities and construction equipments. Details of the contracts including the civil works contracts are summerized in Appendix 7 and 8. The major items procured for the generating equipment and construction equipment followed by International Competitive Bidding according to the IBRD and OECF procurement guideline. Nine firms including five foreign firms were prequalified to bid for the contract of turbines and mechanical equipment in power station No.1 (79/M/001) and submitted their bid documents. The

contract was awarded to the lowest bidder, joint venture with Daewoo Heavy Ind. and Toshiba Corp., on 13 March 1980. And, five firms including four joint-venture were prequalified to bid for the contract of generators and electrical equipments in power station No.1 (79/E/001). But, four firms including three joint - venture submitted their bid documents. The contracts was awarded to the lowest bidder, joint-venture with Daewoo Heavy Ind. and Toshiba Corp., on 13 March 1980. Also the other contracts progressed favorably and the performance ability of the contractors and suppliers was fully satisfactory. Therefore, there were not differculties in following the Bank's guidelines on procurement and no ploblems occured during the Project implementation related to procurement and suppliers, in retrospect.

E. COSTS

3.27 ACTUAL PROJECT COSTS : The estimated cost of the Project at appraisal was US $ 510.0 million, including a foreign exchange cost of US $ 236.0 million. The foreign exchange cost was for the import of construction equipments, materials and machinery, including the generating equipment, and the provision of the consultent's services and the local cost financing. The total actual cost of completion of the Project was US $ 621.9 million, which was about 22 percent above the appraisal estimate.
Detail of the Project actual costs are presented in Appendix 10, summerized in Appendix 9 and annual expenditure of the Project costs shown in Appendix 11.

3.28 COMPARISON OF PROJECT COSTS : The principle reasons for the Project cost diffferance between the appraisal cost estimates and the actual costs are as follows :

1. The cost of the river diversion for the Reregulation Dam was reduced due to selection of alternative, Slurry Trench Cutoff method instead of using the expensive steel sheet piles. (Item A.5 in Appendix 12)

2. Relocation of roads and construction of resettlement sites (Item A.6 in Appendix 12).

- The costs of road relocation were increased for the following reasons :
  - . Design criteria improved.
  - . Addition of asphalt pavement works for 13 Km.
  - . The length of relocation was increased (from 100 Km to 297 Km).

- The costs of railroad relocation was increased for the following reasons :
  - . Design criteria improved.

. Addition of two new stations.
. The length of relocation was increased (from 9 Km to 13 Km).

- Addition of construction of resettlement site such as Danyang, Cheongpung, Hansu, and seven group camps for the displaced persons from inundation area.

3. Cost savings of the powerhouse equipment and gates etc. (Item B & C in Appendix 12) were due to the lowest bidding by International Competative Bidding in following the OECF's guidelines on procurement.

4. The cost of the compensation (Item E in Appendix 12) increased the following reasons :

- Quantity increase.
- Realization of compensation price for inundation area.
- Addition of inundation area in Reregulation reservoir.
- Increasing the protection cost for Dongyang Talc mine.
- Addition of indirect compensation.
- Relocation and prevention countmeasure of cold water demage for Yongkyo irrigation pumping station at just downstream of maindam.

5. The cost of the engineering and administration (Item G in Appendix 12) increased for the following reasons :

- Addition of interest for the IBRD and OECF loan during the construction period.
- Addition of interest for the Oil fund and the KDB fund which was borrowed from the local bank for filling up the shortage of budget.
- Addition of taxes and duties, custom charges, etc. for the imported equipments and materials.

3.29 THE OVERRUNNED COST : It was hard to secure an other financial source for the overruned cost during the construction period. Thus, the overall construction schedule of the Project was expected delay for one year (completed in 1986). But, in the course of reviewing the overall schedule of the Project in late 1983, ISWACO and Government had determined to make availe of the Oil fund and the KDB fund for the overcome of expected delay due to the shortage of budget. Finally, Project execution was back on schedule with targeted completion for 1985. Thus, the Project has completed successfully on schule in late 1985.

F. DISBURSEMENTS

3.30 THE IBRD LOAN : The approved IBRD loan amount of US $ 125 million would make plan to finance 53 % of the foreign exchange requirement of US $ 236 million. The loan of US $ 125 million was for the provision of the consultant's services. the supply of equipments and materials. and local cost financing for the civil works. The final disbursement closed on January 22. 1986. amount of US $ 123.99 million which represented 99 percent against the approved amount of the loan. Details disbursement of the IBRD Loan summarized in Appendix 13. The principal reasons for the difference between the actual disbursements and the approved loan are as follows ;

1. The increase of the disbursements in the civil works category was due to following reason (Item 1 in Appendix 13).

   - The disbursement rate of the loan for local cost financing changed from 45 % to 65 % during the period of 1980 through 1981.
   - The actual volume of landslide treatment of right abutment of the main dam increased (from 5.000.000 cu m to 5.538.000 cu m).
   - The actual escalation rate was higher than anticipated escalation rate.

2. Savings of the actual cost were due to the lowest bidding by the International Compertitive Bidding of the equipments and materials followed to IBRD procurement guideline (Item 2 in Appendix 13).

3. The unallocated category used for local cost financing of the civil works (Item 4 Appendix 13).

On the basis of the revised allocation. the proceeds of the loan was disbursed from 1979 through 1986. The annual disbursement is shown in Appendix 14. There was no serious delay in the disbursement proceeds of the loan and about 99 percent of the approved loan was disbursed. However. to ensure the deficit of local financing budget for the civil works in 1980. the ISWACO proposed early withdrawal of proceeds of the Bank's loan. The proposal was approved by the Bank and the disbursements made in 1979 for the civil work. Besides. the closing date was extended from 30 June 1985 to 31 December 1985. Because some appurtenent works such as accommodation facilities and other minor works for effective maintenance and management of the dam needed some more extended period. Therefore. the disbursement in 1986 was for the costs of its. In the course of this Project. generally. the original disbursement schedule was realistic and the differences between the schedule and actual disbursement was relatively small.

3.31 THE OECF LOAN : An OECF loan amount of Yen 14.000 million (US $ 70 million equipvalent) would finance 30 % of the foreign exchange requirement. The approved loan was for the provision of the consultants services. the supply

of generating equipments. the local cost financing of the civil works and metal works. The final disbursement of the OECF loan closed on February 4. 1986. was Yen 13.213 Million (US $ 66 million equivalent). which represented 94 percent against the approved loan summarized in Appendix 15. The principal reasons for the difference between the actual disbursements and the approved loan are as follows :

1. Savings of the actual cost were due to the lowest bidding by International Competitive Bidding of generating equipments and construction equipments followed to OECF procurement Guideline (Item 1. A) and C) in Appendix 15).

2. The increase of the disbursement in the metal work was due to the additional flood forecast telemetering system for effective operation and maintenance of the flood forecasting facilities (Item 1. B) in Appendix 15)

3. The increase of the disbursement in the engineering service (Item 1. D) in Appendix 15) was due to the additional engineering services for the additional construction supervision according to the extension of the Chungju Project period and addition of power station No.2 in Reregulation dam.

Thus. the proceeds of the loan were disbursed from 1978 through 1986. There was no serious delays and ploblems in the course of disbursement of the loan.

4. FINANCIAL ASPECTS

A. COST ALLOCATION

4.01 There are several way of cost allocation method with some merit and demerit each other. Here. cost allocation method of Chungju Project is applied to seperable costs - remaining benefits method in accordance with stipulation in second article of ordinance relating to Specific Multipurpose Dam Law in Korea. The basic data necessitate for making the cost allocation are as follows :

1. Firstly. the crest elevation for the single purpose. compound and multipurpose dams determined from the needed magnitude of reservoir capacity in order to provide the necessary effects.

2. The construction costs for the single, compound and multipurpose dams are calculated on the basis of stipulation in seventh article of ordinance relating to Specific Multipurpose Dam Law.

3. The annual equvelent benefits for the justifiable investment cost are based on an interest rate of 10 % and an amortization period of 50 years. The result of Capital Recovery Factor (CRF) is 0.1086591. to be multiplied to the construction costs. The Interest During Construction (IDC) for the Project is applied to an actual interest rate of 16 %.

4. The annual operation, maintenance and replacement costs are calculated on the basis of comparative and review against the existing dams.

5. The seperable cost for a given purpose is obtained by subtracting the cost of the compound - purpose project, without that purpose from the cost of the multi - purpose priject which including all functions.

6. Exclusively using facility cost are defined as the costs that serve only one purpose such as the cost of spillway gates and auxilieries for flood control.

7. Appendix 16 indicates a summary of alternative construction costs.

4.02 The basic principles of cost allocation of the Chungju Project are as follows ;

1. All the project cost for the project is allocated justifiably to each purpose.

2. Exclusive cost for only one purpose such as seperable cost or exclusively using facility cost is allocated whole amount to that purpose and it is least allocated cost to that purpose.

3. Maximum allocated cost to each purpose is justifiable investment equivalent to it's own benefit or not more than alternative construction cost for it's own purpose. Basically, smaller cost among the analysed amount according to two way mentioned above is applied.

4. Appendix 17 indicates a cost allocation prepared by seperable costs - remaining benefits method.

Thus, according to method mentioned above, final cost allocation for the Chungju Project is prepared. Appendix 18 represents a final cost allocation for the Chungju Project. On August 28, 1986 ISWACO requested to the MOC to approve the cost allocation for the Project. Finally, MOC approved ISWACO's requested cost allocation on 7 October 1986.

B. POWER TARIFFS

4.03 The study of cost allocation for the Chungju Project was started in December 1984 by the Korea Industrial Development Institute (KID) under the contract between ISWACO and KID. Soon after the commercial power generation was started in May 1985. ISWACO proposed the following power tariffs to the KEPCO based on an interim report of cost allocation prepared by KID.

- Power tariff per KWh : ₩ 45.44
- Share of power generation division : 67.74 %
- Rate of return : 7.8 %
- Estimate of net fixed assets : As of Dec. 31. 1984

4.04 It was agreed between ISWACO and KEPCO in March 1985 that 5.0 % of interest rate should be applied to ISWACO invested net fixed assets for the purpose of calculating the rate of return. A temporary tariff of ₩ 35.48 per KWh was also agreed in December 1985 on the condition that the difference should be settled retroactively after the final agreement on the power tariff is reached.

4.05 Based upon KID's final report on cost allocation. ISWACO proposed following new power tariffs in April 1986.

- Power tariff per KWh : ₩ 45.51
- Share of power generation division : 65.87 %
- Rate of return : 6.6 %
- Estimate of net fixed assets : As of Dec. 31. 1985

4.06 In accordance with Article 8.2 of Industrial Sites and Water Resources Development Promotion Law. ISWACO submitted an application to the Ministry of Construction (MOC) for approval of completion of the Chungju Dam in May 1986. Subsequently. MOC approved it and the following was published in the Official Gazette on October 7. 1986 :

- Owners of the Project facilities
  - . Flood control division : The Government of the Republic
  - . Power and Water division : ISWACO
- Cost allocation of the Project
  - . Flood control division : 16.85 %
  - . Irrigation division : 2.89 %
  - . M & I water division : 14.39 %
  - . Power division : 65.87 %

4.07 After two years of negotiations. agreement has been reached on the power tariffs and the contract is expected to be signed around Dec. 10. 1986 as follows :

- Power tariff per KWh : ₩ 41.10
- Share of power generation division : 61.58 %
- Rate of return : 6.1 %
- Estimate of net fixed assets : As of June 30, 1985

4.08 Taking into account the procedures for conformation on the contract by the Ministry of Energy and Resources, the new power tariffs will be finalized around December 20, 1986.

C. ARRANGEMENTS FOR COMPENSATION FOR WATER SUPPLY AND FLOOD CONTROL

4.09 IRRIGATION WATER : Concerned government authorities are reviewing on the irrigation water charges and one posibility is that the maintenence cost for the related facilities will be borne by the government. In that case the whole share of cost allocated to irrigation division should be deducted from ISWACO's capital.

4.10 M & I WATER : The Ministry of Construction is contemplating on the M & I water charges. It seems most likely that M & I water charges will be set at ₩ 6 per cubic meter for dams in Korea, which is satisfactory to ISWACO. The final decision will be made in December 1986.

4.11 FLOOD CONTROL : Althouugh the economic benefits of flood control would be significant, there is no way in which direct charges could be imposed to recapture these benefits. A major part of the project's flood benefits arise from elimination of flood damage. This, together with more productive land use in the flood plains, will increase revenues to the Government and local authorities, and reduce Government outlays for repair of public facilities and flood relief programs. However, such financial benefits to the Government have not been quantified since they cannot be estimated with any accuracy. Thus, the whole share of cost allocated to flood control was invested as equity contribution to the Project by the Government.

D. ENERGY SALES TO DATE

4.12 The Chungju power station No. 1 and No. 2 were commenced on commercial operation of each units are as follows ;

Chungju power station No. 1 (at Main dam) ;
unit No. 4 : May 15. 1985
unit No. 3 : May 28. 1985
unit No. 1 & 2 : Jun. 14. 1985

Chungju power station No. 2 (at Reregulation dam) ;
unit No. 2 : Jul. 1. 1985
unit No. 1 : Sept. 2. 1985

The power generated is supplied to the KEPCO grid through the Chungju 154 kV transmission line which forms part of the Project. The station is however operated and maintained by ISWACO and power generated is sold in bulk to the KEPCO. The monthly actual gross energy generation auxiliary consumption and net energy supplied to the KEOCO system by Chungju power plant. since its commissioning. are given in Appendix 19. The net energy supplied during the period May. 1985 - Oct. 1986 was lower than the estimate of 844.1 million KWh annual energy generation. The lower energy generation. as compared to the projections made in original study is attributable to the low reservoir levels. In order to derive the energy and power benefits as envisaged originally. the reservoir levels need to be built up by economizing the releases whenever conditions permit.

5. INSTITUTIONAL PERFORMANCE AND DEVELOPMENT

A. CHANGES OF THE ORGANIZATION STRUCTURE

5.01 Despite the important role of Government Invested Enterprises (GIEs) in the national economy. their managerial efficiency has not been up the expected level. The former management system was based on the Government - Invested Enterprise Administration Act and Government - Invested Budget and Account Act. These Acts provided government agencies with many reasons to intervene in the operation of GIEs. which undercut managerial efficiency.

particulary in terms of rapid technological development.
Accordingly, the government enacted the Government - Invested Enterprise Management Act on Dec. 31, 1983, in order to substantially reform the management structure and supervisory system of GIEs. The new Act is aimed at reducing government intervention by establishing a goalerianted system. This system focuses on enhancing the quality while reducing the quantity of government intervention. The Act is aimed at strengthening management autonomy to create conditions in which GIE managers can concentrate their efforts on achieving management objectives. In keeping with the strengthening of management autonomy, a performance evaluation system has also been introduced so as to hold managers accountable for their own performances. Management Organization and Personnel Management has been changed as the following :

- A two - tier management organization has been introduced. The Board of Directors may now approve GIE budgets and major policy objectives, formerly approved by the competent ministries. The presidents of GIEs are in charge of implementation of the decision.

- To prevent possible intervention irto executive activities by the Board, the cheirman of the board and directors of each GIE are non - permanent.

- Related public officials of the competent ministries and Excutive secretary of the Government - Invested Enterprise Management Evaluation Council have seats in the Boards of Directors.

- The President of each GIE appoints his executive staff autonomously, from among existing employees.

- The term of office of executive staff members is three years. However, they can be dismissed if their management performance is poor.

B. PRIORITY OF THE ORGANIZATION

5.82 The Industrial Sites and Water Resources Development Corporation (ISWACO), a government owned corporation, would be responsible for project implementation. ISWACO was established on February 1, 1974 to (a) promote and develop industrial sites for heavy and chemical industries and (b) develop water resources for irrigation, flood control, electric power generation, industrial and municipal water supply. ISWACO's predecessor was the Korea Water Resources Development Corporation (KWRDC) which was established on November 1, 1967 and dissolved on ISWACO's creation. ISWACO had planned and

constructed five industrial esates. three shipyards. and four multipurpose dams. Two new towns. one estuary barrage and three multipurpose dams are presently under construction.

5.03 The main function of ISWACO has not been changed since 1978. but the priority of the projects has been changed from industrial sites development to water resources development projects. ISWACO has been largest organization in the republic of Korea carrying out water resources development projects.

C. MAJOR IMPROVEMENT OF THE ORGANIZATION

5.04 BUDGET MANAGEMENT :

- Management of the budget has been transformed into Management by Objective (MBO) system.
- The presidents has been empowered to formulate his company's budget autonomously. pursuant to the management objectives and the common budget guidelines.

5.05 MATERIAL PROCUREMENT AND ENGINEERING CONTRACTS ;

- The right of self - regulation concerning material procurement and engineering contracts has been given to the president.
- The president may also procure materials and make engineering contracts through the Office of Supply if he wishes to do so.

5.06 AUDIT AND BUSINESS SUPERVISION ;

- Outside audits have been unified into the audit of the Board of Audit and Inspection.
- Inefficient and overlapping business supervision have also been reduced.

5.07 POST EVALUATION SYSTEM :

- The Government - Invested Enterprise Management Evaluation Council has been established in the Economic Planning Board. It is composed of the Minister of EPB. the Ministers of the competent ministries and selected non - government members. The Minister of EPB holds the position of chairman. The major function of the council is to establish basic management policy. formulate common budget guidelines. evaluate management performance. and coordinate government support programs related to GIEs.

- The Minister of EPB may establish the Government - Invested Enterprise Management Evaluation Task Force, which may include relevant experts such as university professors and public accountants, to develop objective methods for performance evaluation.
- Upon completion of performance evaluation, if there are any problems, the Minister of EPB may require the competent Minister to rectify the problems and submit recommendations to the President of the Republic of Korea concerning the dismissal of officers.

D. THE GROWTH OF ISWACO

5.08 The increase of the employees of ISWACO is outstanding since appraisal. The personnel of the main office has been increased up to 607 from 400 and that of the branch offices has been increased up to 975 from 400. ISWACO has 15 branch offices in 1978, but it has been increased up to 21.
The branch offices are as the following :

- Multi - Purpose Dam Construction Office : 3
- Estuary Barrage Construction Office : 1
- Multi - Purpose Dam Operation Office : 6
- Water - Supply Facility Operation Office : 8
- New - Town Construction Office : 2
- Seoul Liasion Office : 1

The organization of ISWACO illustrated in Appendix 20.
The authorized capital of ISWACO has been increased up to 1 trillion Won from 200 thousand million Won since appraisal.

5.09 ISWACO's chief sources of funds are periodic capital subscriptions by the government, loans from KDB, foreign loans and revenues from its operation. Construction of industrial sites is financed partly from the Government's contribution towards capital and by long-term loans from KDB ; after completion, these industrial sites together with related loan obligations are sold to users at a price marginally above cost. Multipurpose dam construction is financed mainly by the Government's capital contribution and foreign loans. The Soyanggang Dam, the Andong Dam and Daechong Dam, owned and operated by ISWACO, provide ISWACO revenues from the sale of energy to KEPCO. The revenues from this energy, determined by contract between KEPCO and ISWACO, cover operating and maintenance costs, and provide a rate of return on a rate base which includes revalued assets and working capital allocated to power. This return is designed to cover debt service assigned to the dams. ISWACO receive revenue on the water supplied from its dams.

5.18 As of December 31. 1977. ISWACO had net assets of ₩ 124.4 billion and as of December 31. 1985. had net assets of about ₩ 1395.8 billion as summirized below :

		Dec. 31. 1977	Dec. 31. 1985
Net current assets	(₩ bill.)	4.23	196.40
Net fixed assets	(₩ bill.)	120.17	1.198.81
Net total assets	(₩ bill.)	124.40	1.395.01
Represented by :			
Long term debt	(₩ bill.)	59.07	516.67
Equity	(₩ bill.)	65.33	878.34

Assets are revalued in accordance with the Assets Appraisal Law of Korea. ISWACO's liquidity position is good. current ratio of 1.34 in 1977 and 1.21 in 1985 are adequate and a Debt/Equity ratio of 47/53 in 1977 and 37/63 in 1985. this provide the capacity for additional borrowing.

6. ECONOMIC REEVALUATION

6.01 In quantifying the Project's benefits. economic values for the economic eevaluation were assigned to the water. the flood control and electrical energy supplied by the Project. Where. the economic values can't be measured directly. such as in the case of energy and municipal water. It was approximated by the conception of alternatives in accordance with the related stipulation and by the datas or the assumptions realized. For power. the construction cost of a thermal plant as alternative to Chungju was applied to power benefits. For M & I water. the economic value is measured by multiplying water price per cubic meter to M & I water demand. For irrigation water. the economic value is estimated in terms of incremental crop production and incremental areas due to Chungju. Flood control benefits have been quantified in terms of reduced damage due to reduced flood risks.
Thus. taking into consideration on the commencing date of commercial operation in power plant No. 1. the basic date of economic reevaluation to estimate the benefits of each purpose for the Chungju Project was taken on 30 June 1985 (exchange rate : US $ 1.00 = ₩ 876.00).
For the purpose of the ex - post analysis for the economic justification. the economic value to express in constant prices of a given year (1979) was exchanged by using the G.N.P. deflator. The costs and the benefits on each purpose were estimated as follows.

6.02 THE COSTS : The costs used for the economic reevaluation. was adjusted by used the G.N.P. deflater which was based on major indicators (established by E.P.B.). Because it is necessary to convert the actual cost described in Appendix 11 to a given base year, 1979 . to eliminate the effect of inflation. Thus. the costs and benefits for the economic reevaluation were expressed in constant prices of a given year. 1979.
Where. financial charges and accounting items. such as interest and handling charge of imported good. were excluded from the actual cost. The differences of the capital were already explained in section 3.28. The operation and maintenance cost were assessed as compared to the organization. the number of persons. the yearly expenditures of the existing project. The replacement cost in accordance with the standard of U.S.B.R. as presented in Appendix 21 was estimated. This. the annual operation. maintenance and replacement cost are taken as US $ 4.38 million.

6.03 POWER BENEFITS : The power benefits were estimated on the basis of a thermal plant as alternative to Chungju in accordance with the stipulation in eighth article in the ordinance relating to Specific Multi - purpose Dam _ Law. Basic principle for obtaining the alternative thermal facility cost per kW was applied to that established by KEPCO and by WASP (Wien Automatic System Planning). Thus. basic standard to obtain power benefit is as follows :

- Alternative thermal :
  - Power plant No. 1 ; Bunker C oil
  - Power plant No. 2 ; Soft coal
  - Increased electric power of the Paldang plant : Bunker C oil
- The alternative thermal facility cost per kW :
  - Bunker C oil ; US $ 588 per kW
  - Soft coal ; US $ 804 per kW
- Dependable power : 352.3 MW
  - Power plant No. 1 ; 345.6 MW
  - Power plant No. 2 ; 6.7 MW
- The annual average energy output : 882.8 GWh
  - Power plant No. 1 ; 764.6 GWh
  - Power plant No. 2 ; 79.5 GWh
  - Increase of Paldang ; 38.7 GWh
- Fixed cost ratio :
  - Bunker C oil ; 13.64 %
  - Soft coal ; 14.87 %
- kW value adjustment factor :
  - Bunker C oil ; 1.20168
  - Soft coal ; 1.25515
- kWh value adjustment factor :
  - Bunker C oil ; 1.01531
  - Soft coal ; 1.03691
- Fuel costs :
  - Bunker C oil (surfur 4 %) ; ₩ 159.130 per liter
  - Soft coal ; ₩ 41.698 per ton

- Fuel consumption amount :
  Bunker C oil : 0.2285 liter per kWh
  Soft coal : 0.3689 kg per kWh
- Calculation method for power benefits :
  . kW value = alternative thermal faci! ty cost x dependable power x fixed cost ratio x adjustment factor
  . kWh value = unit price of fuel costs x fuel consumption amount x annual average energy output x adjustment factor
- Others :
  The period for economic analysis : 50 years
  The discount rate : 10 %

Thus, the annual equivalent power benefits are estimated as about US $ 73 million. In comparison with appraisal expectations, the differances was due to following reasons :

- The increase of annual average energy output was due to additional power plant in Chungju Reregulation dam and increase of energy output at Paldang plant by rising the flow due to operating of the Chungju dam.
- The power benefits was estimated on the conception of alternative thermal plant to Chungju in accordance with the stipulation relating to Specific Multi - purpose Dam Law instead of the average revenue per kWh in Korea on the basis of current tariffs in the appraisal.

6.04 M & I WATER SUPPLY BENEFITS : According to the stipulation in eighth article in the ordinance relating to Specific Multi - purpose Dam Law, the M & I water supply benefits was estimated by multifying water price per cubic meter. The water demand projection was applied to average value of that estimated by ECI's and by KID's (Korea Industrial Development Institute) demand projection forecasted as of 1985. The M & I benefits were obtained as the following principle. Water price per cubic meter and yearly expenditures, including operating, maintenance and replacement cost, were estimated on the conception of least alternative construction cost by the related stipulation in Specific Multi - purpose Dam Law. The water demand projection and benefits summerized and arranged as shown in Appendix 22. Estimated M & I water price according to the above method is ₩ 13.37 per cubic meter.
Where, the differences as compared to appraisal expectations were summarized as follows :

- The full water demands were expected in 2008 instead of 2001 in the appraisal expectations. Thus, the forecasting year of the full water demands was delays seven years.
- According to the stipulation in Specific Multi - purpose Dam Law, the water benefits were estimated on the basis of least alternative construction cost instead of the net economic value of municipal water and the prevailing tariff for raw water withdrawal in the appraisal.

6.05 IRRIGATION WATER SUPPLY BENEFITS : The irrigation water supply benefits were largely devided into the benefit by increase of cultivating area and that due to incremental crop production. The cultivating areas increased

due to the construction of Chungju dam were maden on the basis of the existing data and the data collected by the actual investigation. H.R.W.A. (Han River Water obtained Area) in the ten year planning of agricultural water development. The incremental crop productions due to expension of cultivation area were taken from standard income data for farming and livestock. and from a statistical yearly book established by the Ministry of Agriculture and Fisheries. Thus. the total benefits for the irrigation water demand was estimated by additional benefits with incremental area to that due to improved crop production condition. The differences as compared to appraisal expectations for the irrigation water benefits were resulted from the following reasons ;

- The irrigation water benefit was estimated by the benefits as mentioned above in accordance with the stipulation in article 5 clause 2 in the ordinance relating to Specific Multi - purpose Dam Law. instead of the net economic value of irrigation water in the appraisal expectations.
- The full water demands were represented in 2008. the same as the period of M & I water demand. instead of 2001 in the appraisal expectations. The foreseeing full water demands period was postponed seven years. Thus. the yearly irrigation water demand and irrigation benefits are presented in Appendix 22.

6.06 FLOOD CONTROL BENEFITS ; In order to estimate benefits due to reduction of flood damage. the river below the damsite devide into five flood damage reaches. the same method as estimated in the appraisal. There are three reaches on the South Han (S-1. S-2 and S-3). The downstream reach. S-1. begins at the confluence of the North and South Han and extended beyound its index gage at Yangpyong. The S-2 reach extended further upstream beyond the index gage at Yeoju. and S-3 ends at the damsite and its index gage is at Chungju. The lower Han was devided into two reaches (D-1 and D-2).
The upper reach (D-2) extended below the confluence. and the Koan gage is its index gage. The lower reach (D-1) included Seoul and its index gage is at Indogyo. The flood damage estimate was assumed based on stage - frequency curve and stage - damage curve in HRBR's report and NK's preliminary design report.
Flood damage growth rate was estimated in accordance with the estimating method in HRBR's report and NK's preliminary design report. The studies leading to estimates of benefit due to reduction of flood damage were finally done the same principle as estimated in the appraisal. Thus. the growth rate and benefits due to flood control were presented in Appendix 23. Where. in comparison with appraisal expectations. the differences of flood benefits were due to the following reasons ;

- A little differences of flood damage growth rate were resulted from adopted assumption. In the economic reevaluation. it was adopted the growth rate of the benefits due to flood control to two zones which were the South Han and the lower Han. respectively. instead of integrated zone in the appraisal. That is. to the South Han zone. the growth rate have been assumed to increase of an annual rate of 5 % from 1985 to 2005. at 4 % for the next ten years. at 3.5 % for the

orther next ten years. and at 3 % thereafter. To the lower Han zone. the growth rate have been assumed to increase at an annual rate of 6 % from 1985 to 2000. at 5 % for the next ten years. at 4 % for the other next ten years. at 3.5 % thereafter.

- Benefits due to increased agricultural production were excluded instead of taking into consideration of that in appraisal. Details of flood benefits to two zones are presented in Appendix 23.

6.07 ECONOMIC RATE OF RETURN : Using the foregoing assumptions and the actual investment costs and water supply. power and flood control benefits over a 57 - year evaluation period (including the construction period). the economic internal rate of return has been re-estimated for the whole Project. expressed in 1979 constant values. The economic internal rate of return for the economic reevaluation has been calculated 13.91 percent. compared with 12 percent by the appraisal report. The results of this were summerized and arranged in Appendix 24. The main factor contributing to this higher EIRR was resulted from the increase of annual average energy output due to additional power plant in the Reregulation dam and increase of energy output at Paldang plant by rising the inflow.

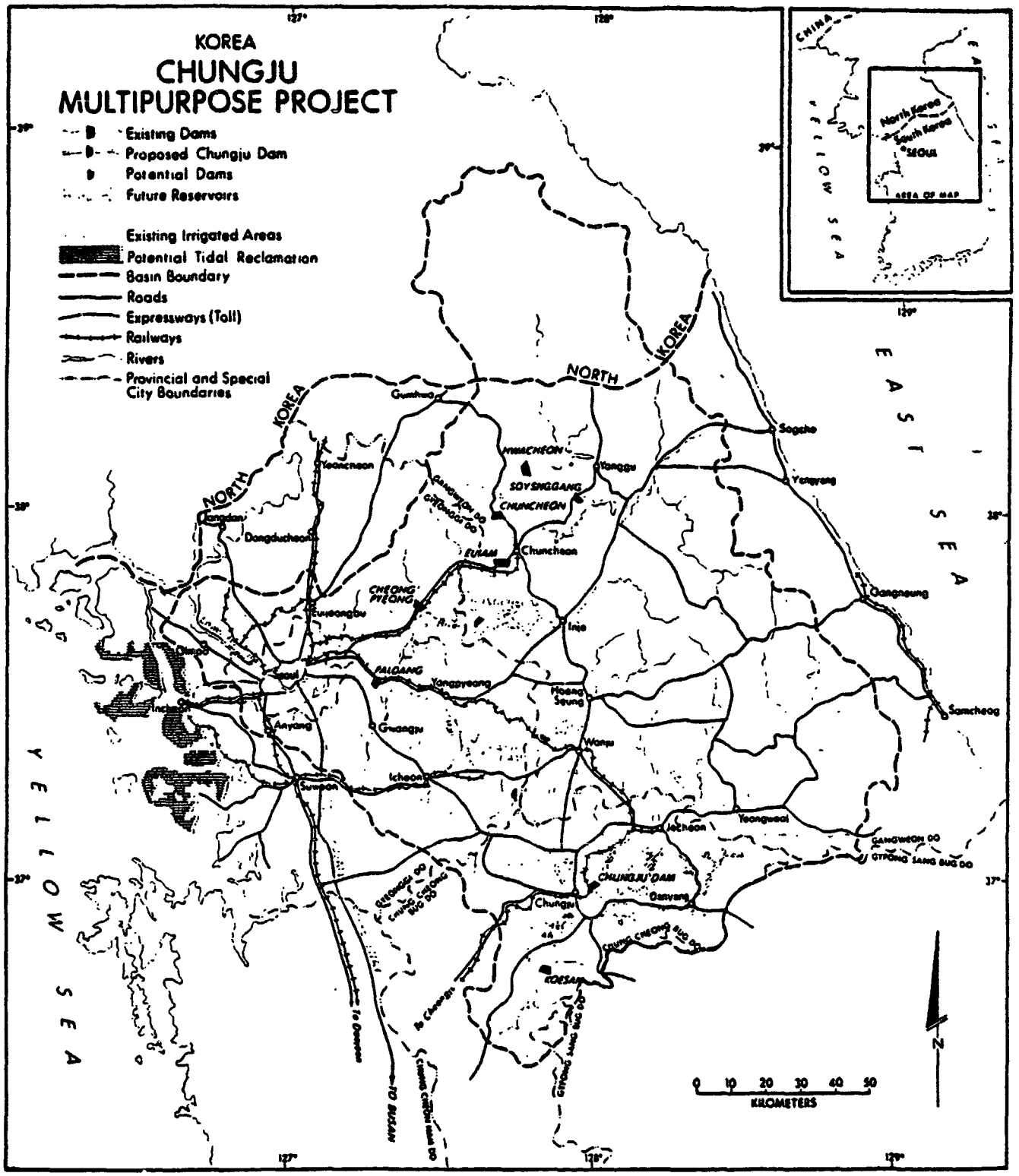
6.08 THE SENSITIVITY TEST : The sensitivity analysis for the internal rate of return has been carried out in the case of adopted same period to the full water demand as estimated in the appraisal (case 1). In this case. it is appraised to be 14.49 percent of EIRR. The results of this presented in Appendix 25. While it is estimated in the case of a 15 - year lag in attaining full water demand (case 2). In this case. the economic rate of return has been appraised at 13.41 percent. The results of this summerized in Appendix 26.

7. BANK PERFORMANCE

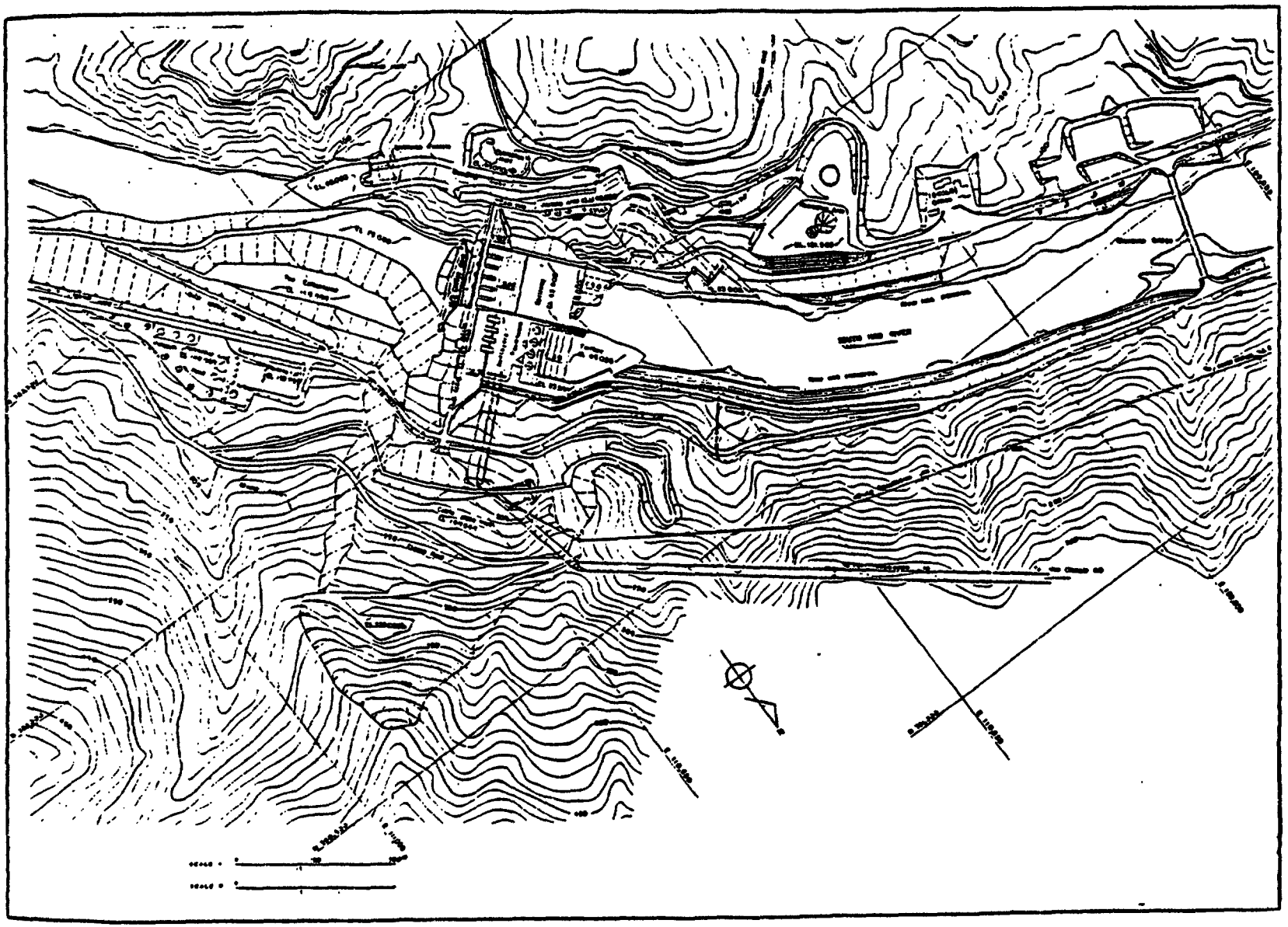
7.01 PROJECT FORMULATION : The comprehensive study of the water resources of the Han River Basin done by the USBR in 1971 gave first priority to the implementation of the Chungju Dam. Also. ECI was implemented the feasibility study about the Chungju Project in 1976 by request of ISWACO and N.K. prepared Preliminary Design Report in 1978. The Chungju Dam at present site with a live storage capacity of 1.789 million cu m would be the most economical means of meeting the agricultural. municipal and industrial water requirements of Han River Basin till 2001. The Project was therefore a well - conceived project for the exploitation of the water resources of the Han River Basin.

7.02 BANK'S PERFORMANCE : The Bank played a very crucial and effective role in the appraisal and implementation of the Project. There was very little delay in the course of appraisal and subsequent loan approval. The close coodination between the Bank and the Excuting Agency resulted in the early appointment of consultants for preperation of a detailed design and construction supervision. Similiarly, the contract for civil works of the dam and power station and procurement of essential equipment were also finalized without delays. The Bank fielded Review Missions and Loan Administration Mission, during the seven - year implementation period. At least one loan review mission visited the Project every year. The period of these missions ranged from four days to ten days each time, which is considered adequate and satisfactory.

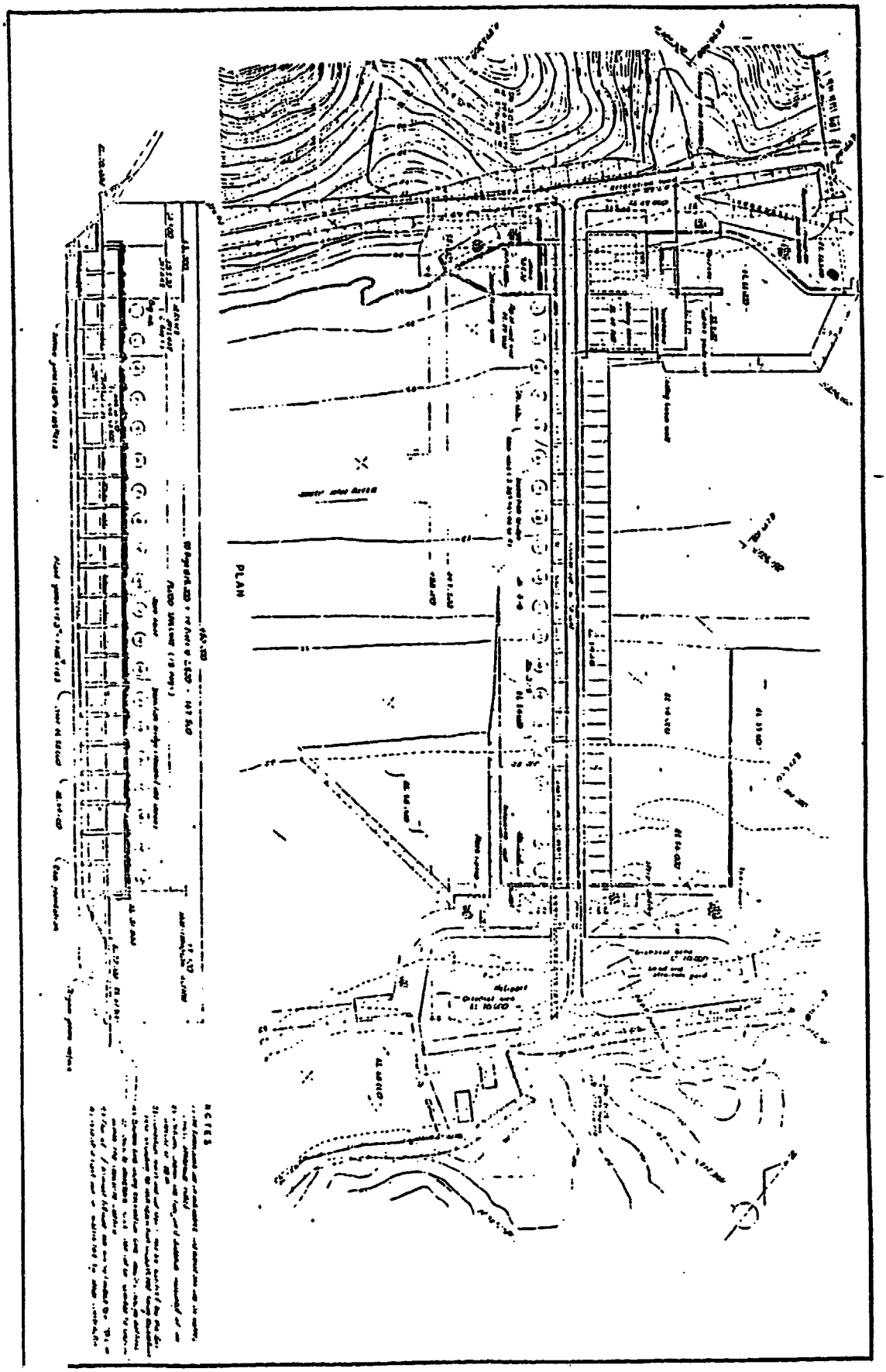
Appendix 1. PROJECT LOCATION MAP



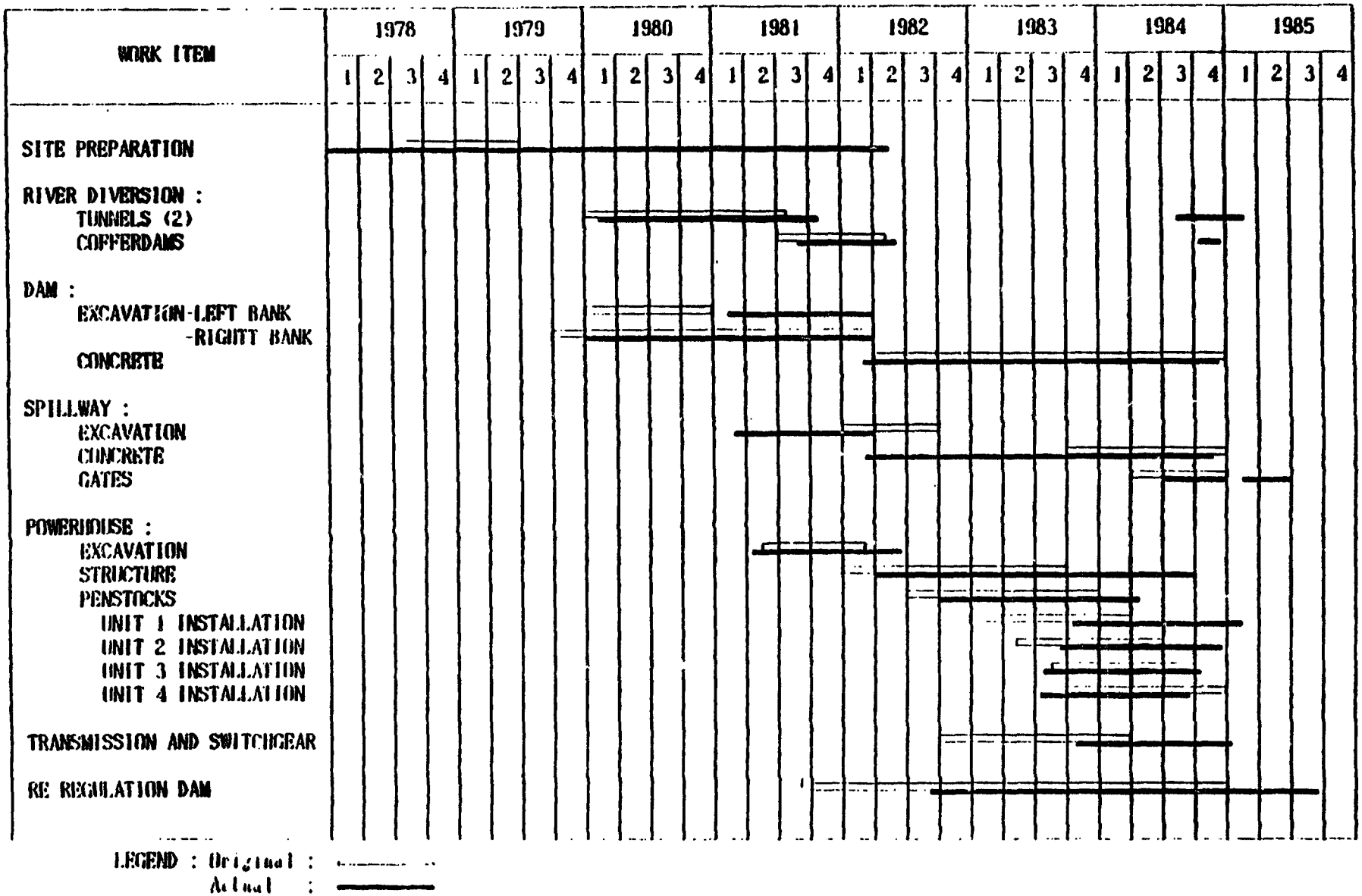
Appendix 2. CHUNGJU DAM GENERAL LAYOUT



Appendix 3. CHUNGJU REREGULATION DAM GENERAL LAYOUT



Appendix 4. PROJECT IMPLEMENTATION SCHEDULE



Appendix 5. SALIENT FEATURES OF THE PROJECT

A. CHUNGJU DAM

1. RESERVOIR

Catchment area	:	6.648 sq km
Annual inflow	:	5.000 million cu m
Maximum reservoir water surface (Flood water level)	:	El. 145.0 m
Conservation pool level.		
Sept. 21 to June 20	:	El. 141.0 m
June 21 to Sept. 20	:	El. 138.0 m
Minimum pool level	:	El. 110.0 m
Reservoir area at El. 141.0 m	:	86 sq km
at El. 145.0 m	:	97 sq km
Reservoir length along water course including backwater at design flood	:	82.5 km
Gross storage capacity before silting.		
at F. W. L. 145.0	:	2.750 million cu m
at H. W. L. 141.0	:	2.385 million cu m
Effective storage before silting	:	1.789 million cu m

2. DAM AND SPILLWAY

Main dam :

Type	:	Concrete gravity dam
Hight above foundation	:	97.5 m
Crest length	:	447 m
Crest elevation	:	El. 147.5 m
Dam concrete volume	:	902.000 cu m

Spillway :

Type	:	Gated free overflow type with stilling basin
Design discharge	:	16.000 cu m / s (corresponding to 500 - year probable flood outflow after reservoir regulation)
Overflow crest elevation	:	El. 126.0 m
Flow width	:	6 bays 15.5 m each + 5 piers 3.5 m each = 110.5 m
Gate	:	6 sets of 15.5 m wide by 17.9 m high radial gate
Gantry crane	:	A 25 - ton capacity motor driven travelling crane to handle stoplogs
Roadway bridge	:	8.5 m wide P.C girder bridge (Design load : DB -24 and gantry crane)

River outlet:

Type	:	Steel - lined conduit (1.65 to 2.8 m dia.) accommodated in dam
Inlet center elevation	:	El. 88.8 m
Discharge capacity	:	54 cu m / s at reservoir water level of El. 141.8 m
Discharge control gate	:	1.65 m dia. jet - flow gate
Protection gate	:	1.65 m dia. ring - follower gate
Number	:	1 set

3. INTAKE AND PENSTOCK

Intake :

Type	:	Bellmouth type, 15.7 m wide and 14.8 m high with trashrack
Gate	:	6.5 m by 6.5 m vertical lift fixed - wheel gate with a 400 mm dia. bypass valve
Numbers	:	4 sets

Steel penstock :

Type	:	Concrete - encased steel penstock
Inner diameter	:	6.5 m to 5.5 m
Length	:	112.6 m - 115.1 m
Number	:	4 sets

4. POWER STATION No.1

Building	:	Surface type powerhouse located on the right abutment at toe of the dam
Tail water level	:	El. 70.8 m (average in plant operation)
Annual energy output	:	764.6 million KWh (average)

Turbine :

Type	:	Vertical shaft Francis type
Runner diameter	:	4.88 m
Rated output	:	4 x 103.1 MW
Rated speed	:	128.5 rpm
Rated head	:	57.5 m
Max. discharge	:	207 cu m / s each
Max. gross head	:	88 m

Generator :

Type	:	Vertical shaft, umbrella type, self ventilation and recirculating type with air cooler, three - phase synchronous generator
Roter diameter	:	9.955 m
Rated output	:	4 x 117.6 MVA at P.F. 0.85 (lagging)
Rated voltage	:	13.8 kV

Frequency	:	60 Hz
Station crane	:	2 x 165 ton capacity bridge crane
Main transformer	:	4 x 149.3 MVA (OFAF), 13.2 kV/154 kV

B. REREGULATION DAM

1. RESERVOIR

Remaining catchment area	:	1,082 sq km
Flood high water level	:	El. 67.3 m
Normal high water level	:	El. 65.1 m (or El. 64.9 m when heavy rain hits Chungju city)
Low water level (Normal)	:	El. 63.5 m
(Extreme)	:	El. 61.8 m
Gross storage capacity (below H.W.L.)	:	29.2 million cu m
Effective storage capacity (between El. 65.1 and 61.8 m)	:	17 million cu m

2. DAM AND SPILLWAY

Non - overflow dam :

Type	:	Concrete gravity dam
Height above foundation	:	19.0 m
Crest length	:	77.5 m
Crest elevation	:	70.0 m

Spillway :

Type	:	Gated free overflow weir type
Design discharge	:	14,800 cu m/s (100-year probable flood)
Overflow crest elevation	:	El. 58.0 m
Flow width	:	20 bays @ 15.0 m + 19 piers @ 2.5 m = 347.5 m (Left bank two bays are for usual service)
Gate	:	Twenty 15 m wide by 7.705 m high vertical lift fixed wheel gates
Stoplog	:	2 sets to be handled by monorail hoist

Roadway bridge :

Type	:	Precast concrete girder
Total length	:	17.5 m x 20 spans = 350 m
Effective width	:	6.0 m
Design load	:	DB - 24

3. INTAKE

Type	:	Horizontal box - flume type with fixed trashrack and raking equipment
Gate	:	Two 11.5 m wide by 8.6 m high vertical lift fixed - wheel gate

4. POWER STATION No.2

Building	:	Semi - underground type concrete building with steel roof trusses located on left abutment just downstream of dam
Tail water level	:	El. 54.45 (average in plant operation)
Annual energy output	:	79.5 million KWh (average)
Turbine :		
Type	:	Horizontal bulb type with movable blade runner
Runner diameter	:	3.3 m
Rated output	:	2 x 6,300 KW
Rated speed	:	171 rpm
Rated head	:	9.2 m
Max. discharge	:	75.3 cu m / s each
Generator :		
Type	:	Horizontal shaft alternating current synchronous generator
Rotor diameter	:	3.037 m
Rated output	:	2 x 7,060 kVA at P.F. 0.85
Rated voltage	:	6.6 kV
Frequency	:	60 Hz
Station crane	:	A 30 - ton capacity bridge crane
Main transformer	:	2 x 7,060 kVA. 6.3 kV/66 kV

5. TRANSMISSION LINE

66 KV transmission line	:	13 km long between power station No. 2 and power station No. 1.

Appendix 6. REALLOCATION OF THE IBRD LOAN

UNIT : US $ THOUSAND

CATEGORY	ORIGINAL ALLOCATION	1ST REALLOCA.	2ND REALLOCA.	ACTUAL DISBURSMENT	BALANCE UNDISBURSED
1. CIVIL WORKS	78.000	97.700	97.090	96.177	913
A) MOBILIZATION FOR PART A OF THE PROJECT	5.000	5.000	5.000	5.000	0
B) CIVIL WORKS	73.000	92.700	92.090	91.177	913
79/C/001					-
82/C/002					
RAILROAD					
2. EQUIPMENT AND MATERIALS	37.000	25.000	25.774	25.755	19
A) EQUIPMENT AND MATERIALS					
B) EQUIPMENT (82/C/002)					
C) EQUIPMENT (82/M/003)					
3. TECHNICAL ASSISTANCE	2.000	2.300	2.136	2.058	78
A) CONSULTANT'S SERVICES		2.150	1.986	1.978	8
1) NAKDONG					
2) CONSULTING PANEL					
B) OVERSEAS TRAINING		150	150	80	70
4. UNALLOCATED	8.000	0	0	0	0
TOTAL	125.000	125.000	125.000	123.990	1.010

Appendix 7. CONTRACTS UNDER IBRD'S PROCUREMENT GUIDELINE

CONTRACT NO.	WORK	CONTRACTOR	CONTRACT DATE
79/C/001	CIVIL WORKS FOR CHUNGJU DAM AND POWER STATION INCLUDING INSTALLATION OF GATES & PENSTOCKS	HYUNDAI ENGINEERING AND CONSTRUCTION	DEC.18.1979
82/C/002	CIVIL WORKS FOR REREGULATION DAM AND POWER STATION NO.2 INCLUDING METAL WORKS FOR GATES	HYUNDAI ENGINEERING AND CONSTRUCTION	AUG.28.1982
82/R/001	CIVIL WOEKS FOR JUNGANG RAILROAD LINE (DODAM-JUGNYEONG) RELOCATION	DAEWOO CO.	DEC. 3.1982
82/M/003	SUPPLY OF SPILLWAY & INTAKE GATES, STOPLOGS AND GANTRY CRANE	HYUNDAI ENGINEERING AND CONSTRUCTION	JAN.26.1983

* Some contracts for funished materials Cement & Reinforcement Steel Bar was not included in this table

Appendix 8. CONTRACTS UNDER OECF'S PROCUREMENT GUIDELINE

CONTRACT NO.	WORK	CONTRACTOR	CONTRACT DATE
79/M/001	TURBINES AND MECHANICAL EQUIPMENTS IN POWER STATION NO. 1	DAEWOO HEAVY IND./ TOSHIBA CORP.	MAR.13.1980
79/E/001	GENERATORS AND ELECTRICAL EQUIPMENTS IN POWER STATION NO. 1	DAEWOO HEAVY IND./ TOSHIBA CORP	MAR.13.1980
	SUPPLY OF CABLE CRANES	ISHIKAWAJIMA-HARIMA HEAVY IND.	JUL. 9.1980
82/M/002	DESIGN OF SPILLWAY & INTAKE GATES AND SUPPLY OF THEIR HOISTS AND RIVER OUTLET GATES	HYUNDAI HEAVY INDUSTRY	JUL.24.1981
81/F/001	FLOOD FORECASTING SYSTEM	DAEYOUNG ELECTRONICS IND./MATSUSHITA COMMUNICATION IND.	MAR.11.1982
82/E/003	POWER PLANTS. TRANSFORMERS & SWITCH GEARS FOR POWER STATION NO. 2	KOREA HEAVY IND. AND CONSTRUCTION / FUJI ELECTRIC	DEC.28.1982
82/E/002	SUPPLY OF HIGH VOLTAGE SWITCH GEARS AND INSULATORS	NISSHO-IWAI CORP./ C. ITOH & CO.	JUL.25.1983

Appendix 9. SUMMARY OF THE PROJECT COSTS

EXCHANGE RATE : US $ 1.00 = W 892.50
(DEC.31,1985)

CATEGORY	LOCAL (W BILL.)	FOREIGN (W BILL.)	TOTAL (W BILL.)	LOCAL ($ MILL.)	FOREIGN ($ MILL.)	TOTAL ($ MILL.)	FOREIGN EXCHANGE (%)
A. CIVIL WORKS							
1. SITE PREPA. AND BUILD	2.05	4.01	6.07	2.30	4.50	6.80	66.14
2. RIVER DIVERSION	2.91	8.93	11.84	3.27	10.01	13.27	75.40
3. DAM AND SPILLWAY	24.09	73.82	97.91	26.99	82.71	109.70	75.40
4. POWER HOUSE	3.28	10.04	13.31	3.67	11.25	14.92	75.40
5. REREGULATING DAM	1.89	3.78	5.67	2.12	4.24	6.36	66.70
6. RELOCATION AND PROTECTIVE WORKS	106.32	7.02	113.34	119.12	7.87	126.99	6.19
SUBTOTAL	140.54	107.60	248.14	157.47	120.56	278.03	43.36
B.GATES.GUIDES AND HOISTS	4.39	10.37	14.76	4.92	11.62	16.54	70.25
C.POWERHOUSE EQUIPMENT	24.49	28.27	52.76	27.44	31.68	59.12	53.58
D.FURNISHED MATERIALS	4.34	14.93	19.77	5.42	16.73	22.15	75.53
E.COMPENSATION	153.82	0.00	153.82	172.35	0.00	172.35	0.00
F.CONSULTANTS	0.68	8.18	8.86	0.76	9.16	9.92	92.35
G.ENGINEERING AND ADMIN.	56.93	0.00	56.93	63.79	0.00	63.79	0.00
TOTAL PROJECT COST	385.69	169.36	555.05	432.15	189.75	621.90	30.51

• ACTUAL COST WAS INCUDED PRICE ESCALATION

Appendix 10. DETAIL ACTUAL COST

EXCHANGE RATE : US $ 1.00 = W 892.50
(DEC.31,1985)

CATEGORY	UNIT	QUANTITIES	UNIT PRICE (US $)	AMOUNT(US $ MILLION) TOTAL	LOCAL	FOREIGN
A. CIVIL WORKS						
1.SITE PREPARATION AND BUILDINGS						
-ACCESS & CONSTR. ROAD	L.S			5.96	1.47	4.50
-ISWACO HOUSING AND OFFICE	L.S			0.83	0.83	0.00
-CONTRACTOR'S CAMPS	L.S					
-SITE INVESTIGATIONS	L.S					
-RESERVOIR CLEARING	SQ KM				-	
SUBTOTAL		1		6.80	2.30	4.50
2.RIVER DIVERSION						
-PORTAL EXCAVATION	CU M	265,000	9	2.29	0.56	1.73
-COFFERDAMS	L.S			1.59	0.39	1.20
-TUNNEL EXCAVATION	CU M	183,000	21	3.78	0.93	2.85
-TUNNEL LINING	CU M	41,000	91	3.72	0.92	2.81
-TUNNEL SUPPORTS	TON	228	1,499	0.34	0.08	0.26
-REINFORCING STEEL	TON	700	350	0.25	0.06	0.18
-DRILLING AND GROUTING	L.S			0.19	0.05	0.15
-MINOR ITEMS	L.S	DIVERSION CLOSURE INCLUDED		1.11	0.27	0.84
SUBTOTAL				13.27	3.27	10.01
3.DAM AND SPILLWAY						
-EARTH EXCAVATION	CU M	531,000	3	1.48	0.36	1.12
-ROCK EXCAVATION	CU M	5,937,000	10	59.36	14.75	45.20
-MASS CONCRETE/a	CU M	902,000	14	12.66	3.12	9.55
-STRUCTURAL CONCRETE/a	CU M	170,000	12	2.02	0.50	1.52
-REINFORCING STEEL/b	TON	8,200	167	1.37	0.34	1.03
-DRILLING AND GROUTING	L.S			2.79	0.69	2.10
-MINOR ITEMS	L.S			29.43	7.24	22.19
SUBTOTAL				109.70	26.99	82.71
4.POWER HOUSE						
-EARTH EXCAVATION	CU M	160,000	2	0.33	0.08	0.25
-ROCK EXCAVATION	CU M	484,000	11	5.34	1.31	4.03
-STRUCTURAL CONCRETE/a	CU M	64,000	96	6.15	1.51	4.63

CATEGORY	UNIT	QUANTITIES	UNIT PRICE (US $)	AMOUNT(US $ MILLION) TOTAL	LOCAL	FOREIGN
-REINFORCING STEEL/b	TON					
-BACKFILL	CU M	50,000	15	0.76	0.19	0.57
-MINOR ITEMS	L.S			2.35	0.58	1.77
SUBTOTAL				14.92	3.67	11.25
5.REREGULATING DAM						
-EARTH EXCAVATION	CU M	208,000	1	0.19	0.06	0.13
-ROCK EXCAVATION	CU M	47,000	5	0.24	0.08	0.16
-EMBANKMENT FILL	CU M					
-SLOPE PROTECTION	SQ M					
-MASS CONCRETE/a	CU M	65,000	53	3.42	1.14	2.28
-STRUCTURAL CONCRETE/a	CU M	31,000	19	0.59	0.20	0.40
-REINFORCING STEEL/b	TON	2,400	38	0.09	0.03	0.06
-BRIDGE	L.S			0.16	0.05	0.10
-MINOR ITEMS	L.S			1.67	0.55	1.11
SUBTOTAL				6.36	2.12	4.24
6.RELOCATION AND PROTECTIVE WORKS						
1)ROAD RELOCATION						
-EARTH WORK AND PAVING	KM	297				
-BRIDGE	M	2,728				
-LAND	HA	572				
SUBTOTAL				84.77	84.77	0.00
2)RAIL RELOCATION						
-EARTH WORK AND PAVING	KM	13				
-BRIDGE	M	850				
-TUNNELS	M	1,810				
-LAND	HA	92				
SUBTOTAL				28.70	20.83	7.87
3)RESETTLEMENT	L.S			13.52	13.52	0.00
4)POWER FACILITIES		INCLUDED IN MAINDAM				
-DISTRIBUTION LINES	KM					
-SUBSTATIONS	NO					
5)PROTECTIVE WORKS		INCLUDED IN COMPENSATION				
-DONGYANG TALC MINE	L.S					
-SUNGSIN CEMENT PLANT	L.S					
-MISCELLANEOUS	L.S					

CATEGORY	UNIT	QUANTITIES	UNIT PRICE (US $)	AMOUNT(US $ MILLION) TOTAL	LOCAL	FOREIGN
6)PUBLIC BUILDINGS	L.S	INCLUDED IN COMPENSATION				
TOTAL				126.99	119.12	7.87
• TOTAL CIVIL WORKS				278.03	157.47	120.56
B. GATES.GUIDES AND HOISTS						
1.DIVERSION CLOSURE	TON	INCLUDED IN DIVERSION				
2.SPILLWAY	TON	1,978	3,851	7.62	1.44	6.18
3.POWER INTAKES	TON	908	4,205	3.82	0.72	- 3.10
4.REREGULATING DAM	TON	1,400	1,846	2.58	2.28	0.30
5.DRAFT TUBE	TON					
6.STOPLOGS	TON	517	4,872	2.52	0.48	2.04
7.CRANES	L.S					
8.RIVER OUTLET VALVE	L.S					
TOTAL				16.54	4.92	11.62
C. POWERHOUSE EQUIPMENT						
1.TURBINES. GOVERNORS AND VALVE	NO	4	3,659,104	14.64	7.72	6.92
2.GENERATORS	NO	4	4,597,479	18.39	3.57	14.82
3.TRANSFORMERS	NO	4	1,265,546	5.06	4.79	0.27
4.PENSTOCK	TON	2,000	3,030	6.06	6.06	0.00
5.POWERHOUSE CRANE	L.S					
6.SWITCHGEAR	L.S					
7.TRANSMISSI' .NES	KM			1.85	1.85	0.00
8.MISC.ELEC.. AL EQUI	L.S	INCLUDED IN GENERATORS				
9.MISC.MECHANICAL EQUI	L.S	INCLUDED IN TURBINES				
10.TELEMETERING	L.S	NEW ITEM		3.63	0.18	3.45
11.EQUIPMENT FOR NO.2	L.S	NEW ITEM		9.49	3.27	6.22
TOTAL				59.12	27.44	31.68
D.FURNISHED MATERIALS						
1.CEMENT	TON	296.000	56	16.71	4.09	12.62
2.REINFORCING STEEL	TON	17.400	313	5.44	1.33	4.11
TOTAL				22.15	5.42	16.73

CATEGORY	UNIT	QUANTITIES	UNIT PRICE (US $)	AMOUNT(US $ MILLION) TOTAL	LOCAL	FOREIGN
E.COMPENSATION FOR LAND AND PPROPERTY						
1.PADDY LAND	HA	2,747	12,922	35.50	35.50	0.00
2.UPLAND	HA	1,668	20,195	33.69	33.69	0.00
3.BUILDING LAND	HA	241	94,085	22.67	22.67	0.00
4.FOREST	HA	2,277	1,494	3.40	3.40	0.00
5.FRUIT TREES	NO					
6.MULBERRY BUSHES	NO	2,115,836	2	3.57	3.57	0.00
7.HOUSES	NO	22,118	1,480	32.74	32.74	0.00
8.GRAVES	NO	14,559	108	1.58	1.58	0.00
9.SMALL BUSINESSES	NO	1,511	2,391	3.61	3.61	0.00
10.REMOVAL EXPENSE	FAMILIE	6,452	132	0.85	0.85	0.00
11.SUBSISTENCE	PERSONS	28,381	202	5.74	5.74	0.00
12.MINERAL RIGHTS	L.S			1.92	1.92	0.00
13.PUBLIC BUILDING	NO	431	10,859	4.68	4.68	0.00
14.CULTURAL RESOURCES	NO	102.00	18,103	1.85	1.85	0.00
15.OTHER FACILITIES	L.S			3.13	3.13	0.00
16.PUMP HOUSE	L.S			3.38	3.38	0.00
17.CONSTRUCTION LAND	HA	193.00	65,212	12.59	12.59	0.00
18.MINOR ITEMS	L.S	(NO13-NO18 NEW ITEM)		1.44	1.44	0.00
TOTAL				172.35	172.35	0.00
F.CONSULTING SERVICES AND ISWACO COSTS						
1.PROJECT CONSULTANTS	L.S			7.95	0.76	7.19
2.CONSULTING PANEL	L.S			0.33	0.00	0.33
3.PRECONSTRUCTION ENGINEERING(NAKDONG)	L.S			1.75	0.00	1.75
4.ENGINEERING AND ADMINISTRATION	L.S	ADDED INTEREST OF THE LOAN AND THE FUND		63.79	63.79	0.00
TOTAL				73.71	64.55	9.16
GRAND TOTAL				621.90	432.15	189.75

- ACTUAL COST WAS INCLUDED PRICE ESCALATION

/a Excludes supply of cement but includes from work.
/b Placement only.

Appendix 11. ANNUAL EXPENDITURE OF THE PROJECT COST

UNIT ; US $ MILLION
EXCHANGE RATE : US $ 1.00 = W 892.50
(DEC.31,1985)

CATEGORY	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
A. CIVIL WORKS									
1.SITE PREPA. AND BUILDINGS	0.50	0.34	2.05	2.21	0.35	0.26	0.20	0.87	6.80
2.RIVER DIVERSION	0.00	0.00	5.13	5.56	0.83	0.28	1.22	0.25	13.27
3.DAM AND SPILLWAY	0.00	0.00	21.26	33.25	17.78	15.29	1.12	21.00	109.70
4.POWER HOUSE	0.00	0.00	0.00	4.98	3.58	2.91	1.99	1.43	14.92
5.REREGULATING DAM	0.00	0.00	0.00	0.90	0.76	2.54	2.85	0.21	6.36
6.RELOCATION AND PROTECTIVE	0.00	0.00	0.00	0.00	7.89	29.88	60.01	29.19	126.99
SUBTOTAL	0.50	0.34	28.43	16.03	31.19	51.20	67.39	52.95	278.03
B. GATES,GUIDES AND HOISTS	0.00	0.00	0.00	0.03	0.51	6.03	9.39	0.57	16.54
C. POWERHOUSE EQUIPMENT	0.00	0.00	2.08	1.06	11.56	17.64	23.89	2.89	59.12
D. FURNISHED MATERIALS	0.09	0.05	0.14	5.45	6.86	4.64	3.86	1.07	22.15
E. COMPENSATION	0.13	0.02	0.47	13.16	40.04	91.60	16.06	10.87	172.35
F. CONSULTANTS	0.76	1.07	1.16	2.14	2.04	0.86	0.91	0.98	9.92
G. ENGINEERING AND ADMIN. (incl. Int. during Cons)	1.40	0.95	1.97	6.05	7.67	12.41	16.15	16.89	63.79
TOTAL EXPENDITURE	2.89	2.42	34.25	73.91	99.87	184.38	137.97	86.22	621.90

Appendix 12. COMPARISON OF THE PROJECT COSTS

UNIT : US $ MILLION
EXCHANGE RATE : US $ 1.00 = W 485.00 (Appraisal)
US $ 1.00 = W 892.50 (Dec.31.1985)

CATEGORY	A APPRAISAL	B APPRAISAL (INCL.ESCAL.)	C ACTUAL	C-A DIFFERENCE	C-B DIFFERENCE
A. CIVIL WORKS					
1. SITE PREPA. AND BUILDINGS	12.6	13.0	6.8	(5.3)	(6.2)
2. RIVER DIVERSION	12.0	13.2	13.3	1.3	0.1
3. DAM AND SPILLWAY	83.9	104.1	109.7	25.8	5.6
4. POWER HOUSE	13.1	17.1	14.9	1.3	(2.2)
5. REREGULATING DAM	10.9	14.0	6.4	(4.5)	(7.6)
6. RELOCATION AND PROTECTIVE WORKS	38.0	46.0	127.0	89.0	81.0
SUBTOTAL	170.5	207.4	278.0	107.5	70.6
B. GATES.GUIDES AND HOISTS	23.4	29.3	16.5	(6.9)	(12.8)
C. POWERHOUSE EQUIPMENT	75.9	95.7	59.1	(16.8)	(36.6)
D. FURNISHED MATERIALS	15.7	17.7	22.2	6.5	4.5
E. COMPENSATION	109.0	127.9	172.3	69.8	44.4
F. CONSULTANTS	7.0	8.1	9.9	2.9	1.8
G. ENGINEERING AND ADMIN.	20.0	23.9	63.8	43.8	39.3
H. EXPECTED PRICE INCREASES	88.5	0.0	0.0	(88.5)	0.9
TOTAL PROJECT COST	510.0	510.0	621.9	111.9	111.9

* ACTUAL COST WAS INCUDED PRICE ESCALATION
* ( ) MEANS REDUTION

Appendix 13. DETAIL DISBURSEMENT OF THE IBRD LOAN

UNIT : US $ MILLION

CATEGORY	A ORIGINAL	B REVISED	C ACTUAL	C-A DIFFERENCE	C-B DIFFERENCE
1. CIVIL WORKS	78.00	97.09	06.18	18.18	(0.91)
A) MOBILIZATION FOR PART A OF THE PROJECT	5.00	5.00	5.00	0.00	0.00
B) CIVIL WORKS	78.00	92.09	91.18	18.18	(0.01)
79/C/001			79.07		-
82/C/002			4.24		
RAILROAD			7.87		
2. EQUIPMENT AND MATERIALS	37.00	25.77	25.76	(11.24)	(0.01)
A) EQUIPMENT AND MATERIALS			16.73		
B) EQUIPMENT (82/C/002)			0.30		
C) EQUIPMENT (82/M/003)			8.73		
3. TECHNICAL ASSISTANCE	2.00	2.14	2.06	0.06	(0.08)
A) CONSULTANT'S SERVICES		1.99	1.98	1.98	(0.01)
1) NAEDONG			1.75		
2) CONSULTING PANEL			0.23		
B) OVERSEAS TRAINING		0.15	0.08	0.08	(0.07)
4. UNALLOCATED	8.00	0.00	0.00	(8.00)	0.00
TOTAL	125.00	125.00	123.99	(1.01)	(1.01)

* ( ) MEANS REDUCTION

Appendix 14. ANNUAL DISBURSEMENT OF THE IBRD LOAN

UNIT : US $ MILLION

YEARS	ORIGINAL PLAN AMOUNT	CUMULATIVE	DISBURSED AMOUNT	CUMULATIVE
1979			5.03	
1980	9.30		15.23	20.26
1981	22.70	32.50	31.89	52.15
1982	30.30	62.80	21.05	73.20
1983	28.40	91.20	20.83	94.03
1984	23.50	114.70	23.02	117.05
1985	10.30	125.00	6.21	123.26
1986			0.73	123.99
TOTAL	125.00	125.00	123.00	123.09

Appendix 15. DETAIL DISBUREMENT OF THE OECF LOAN

UNIT : US $ MILLION

CATEGORY	A ORIGINAL	B REVISED	C ACTUAL	C-A DIFFERENCE	C-B DIFFERENCE
1. FOREIGN CURRENCY	55.00	49.01	45.07	(9.93)	(3.94)
A) GENERATING EQUIPMENT	35.00	28.41	28.32	(6.68)	(0.09)
1) TURBINE & GENERATOR			28.05		
79/E/001			14.87		
79/M/001			6.94		-
82/E/003			6.24		
2) SUBSTATION EQUIPMENT (82/E/002)			0.27		
B) METAL WORK	4.05	6.13	6.06	2.01	(0.06)
1) TELEMETERING			3.46		
2) GATES AND HOISTS (80/M/002)			2.60		
C) CONSTRUCTION EQUIPMENT (CABLE CRANE)	3.60	3.48	3.48	(0.12)	(.00)
D) ENGINEERING SERVICE	4.30	7.46	7.21	2.41	(0.24)
E) CONTINGENCY	7.55	3.55	0.00	(7.55)	(3.55)
2. LOCAL COST FINANCING	15.00	20.99	20.99	5.99	.00
79/C/001			20.54		
BACHER PLANT			0.45		
TOTAL	70.00	70.00	66.06	(3.94)	(3.94)

*. ( ) MEANS REDUCTION

Appendix 16. SUMMARY OF ALTERNATIVE CONSTRUCTION COST FOR COST ALLOCATION

UNIT: ₩ MILLION

ITEM	SINGLE-PURPOSE DAM				COMPOUND-PURPOSE DAM				MULTI-PURPOSE DAM
	FLOOD CONTROL	IRRIGATION	M. & I.	POWER	IRR.+POWER -M.&I.	FLOOD+M&I +POWER	FLOOD+IRR +POWER	FLOOD+IRR +M.&I.	
DAM CREST ELEVATION(M)	118.5	107.5	134.5	143.5	143.5	147.5	147.5	140.0	147.5
1.WORKING COST	50.775	31.510	81.434	171.530	172.595	188.068	187.571	105.109	188.302
1)TEMPORARY FACILITY AND BUILDINGS	1.754	1.445	3.203	4.354	4.354	4.467	4.467	2.442	4.467
2)DAM EMBENKMENT	47.154	30.023	78.900	108.444	109.136	122.371	122.463	100.434	122.063
-MAIN DAM AND SPILLWAY	47.154	28.777	76.824	99.858	99.858	113.785	113.785	98.269	113.785
-EMERGENCY WATERWAY	-	92	600	-	692	600	92	600	692
-ADDITIONAL WATER SUPPLY EQUIPMENT	-	1.154	1.476	-	-	-	-	1.565	-
-POWER STATION FOUNDATION	-			8.586	8.586	8.586	8.586		8.586
3)GENERATING EQUIPMENT	0	0	0	39.443	39.443	39.443	39.443	0	39.443
- TAILBAY	-	-	-	2.710	2.710	2.710	2.710	-	2.710
- INTAKE STRUCTURE	-	-	-	3.576	3.576	3.576	3.576	-	3.576
- PENSTOCK	-	-	-	1.148	1.148	1.148	1.148	-	1.148
- TURBINE. GENERATER	-	-	-	22.972	22.972	22.972	22.972	-	22.972
- WATERWAY STRUCTURE	-	-	-	4.274	4.274	4.274	4.274	-	4.274
-SWITCHYARD.TRANSFORMER EQUIPMENT	-	-	-	4.763	4.763	4.763	4.763	-	4.763
4)TRANSMISSION LINE	-	-	-	1.463	1.463	1.463	1.463	-	1.463
5)FLOOD FORECASTING	1.867	42	331	455	828	2.853	2.364	2.240	2.695
6)REREGURATION DAM	-	-	-	17.371	17.371	17.371	17.371	-	17.371
- DAM EMBENKMENT	-	-	-	10.098	10.098	10.098	10.098	-	10.098
- NO.2 POWER STATION	-	-	-	7.273	7.273	7.273	7.273	-	7.273
2.COMPENSATION COST	74.039	45.379	200.387	237.011	237.011	266.467	266.467	233.333	266.467
3.ENGINEERING AND ADMIN.	3.757	2.002	7.421	17.415	18.330	19.257	19.116	9.431	19.278
4.INTEREST DURING CONSTR.	20.571	9.464	57.949	102.227	102.704	113.782	113.556	69.823	113.819
GRAND TOTAL	149.142	88.355	347.631	528.183	530.640	587.874	586.710	417.736	588.066

Appendix 17. COST ALLOCATION BY SEPARABLE COSTS-REMAINING BENEFITS METHOD

UNIT: ₩ MILLION

ITEM	FLOOD CONTROL	IRRIGATION	M. & I.	POWER	TOTAL
A. COST ALLOCATION					
1. ALTERNATIVE COST	149.142	88.354	347.691	528.173	
2. JUSTIFIABLE EXPENDITURES	122.875	25.693	127.405	499.151	
3. APPLICABLE	122.875	25.693	127.405	499.151	
4. SEPARABLE COST	57.426	192	1.356	170.316	229.290
5. REMAINING BENEFITS	65.449	25.501	126.049	328.835	545.834
6. PROPORTION(%) (5/5(TOTAL))	(11.99)	(4.67)	(23.09)	(60.25)	(100.0)
7. ALLOCATION OF JOINT COST	43.017	16.755	82.841	216.163	358.776
8. TOTAL ALLOCATION (4+7)	100.443	16.947	84.197	386.479	588.066
9. PROPORTION(%) (9/9(TOTAL))	(17.08)	(2.88)	(14.32)	(65.72)	(100.0)
B. PROPORTION(%) FOR JOINT USING FACILITIES					
1. ALLOCATION COST OF CONSTRUCTION COST	90.176	15.205	75.605	346.978	527.964
2. EXCLUSIVELY USE FACILITY COST	3.200	212	1.488	97.197	102.097
3. ALLOCATION COST FOR JOINT USING FACILITIES	86.976	14.993	74.117	249.781	425.867
4. PROPORTION(%) (4/4(TOTAL))	(20.43)	(3.52)	(17.40)	(58.65)	(100.0)

Appendix 18. FINAL COST ALLOCATION FOR THE CHUNGJU MULTIPURPOSE RPOJECT

UNIT: ₩ MILLION

ITEM	FLOOD CONTROL	IRRIGATION	M. & I.	POWER	TOTAL
1.JOINT USING FACILITIES (%)	91.572 (20.43)	15.777 (3.52)	77.991 (17.40)	262.883 (58.65)	448.223 (100.0)
1) STRUCTURE	88.587	15.263	75.448	254.312	433.610
2) WATERWAY EQUIPMENT (SPILLWAY)	2.985	514	2.543	8.571	14.613
2. EXCLUSIVELY USE FACILITY	1.535	175	1.510	100.974	104.194
1) BUILDINGS	-	-	-	5.280	5.280
2) STRUCTURE	-	-	-	16.312	16.312
3) WATERWAY EQUIPMENT	-	95	819	10.145	11.059
- INTAKE STRUCTURE	-	-	-	5.578	5.578
- RIVER OUTLET FACILIT	-	95	819	-	914
- PENSTOCK	-	-	-	3.944	3.944
- TAILBAY	-	-	-	623	623
4) REREGURATION DAM	-	-	-	14.072	14.072
5) GENERATING EQUIPMENT	-	-	-	52.624	52.624
6) FLOOD FORECASTING FACILITIES	1.535	80	691	2.541	4.847
SUBTOTAL (%)	93.107 (16.85)	15.952 (2.89)	79.501 (14.39)	363.857 (65.87)	552.417 (100.0)
3. OTHERS	-	-	-	-	2.630
GRAND TOTAL	93.107	15.952	79.501	363.857	555.047

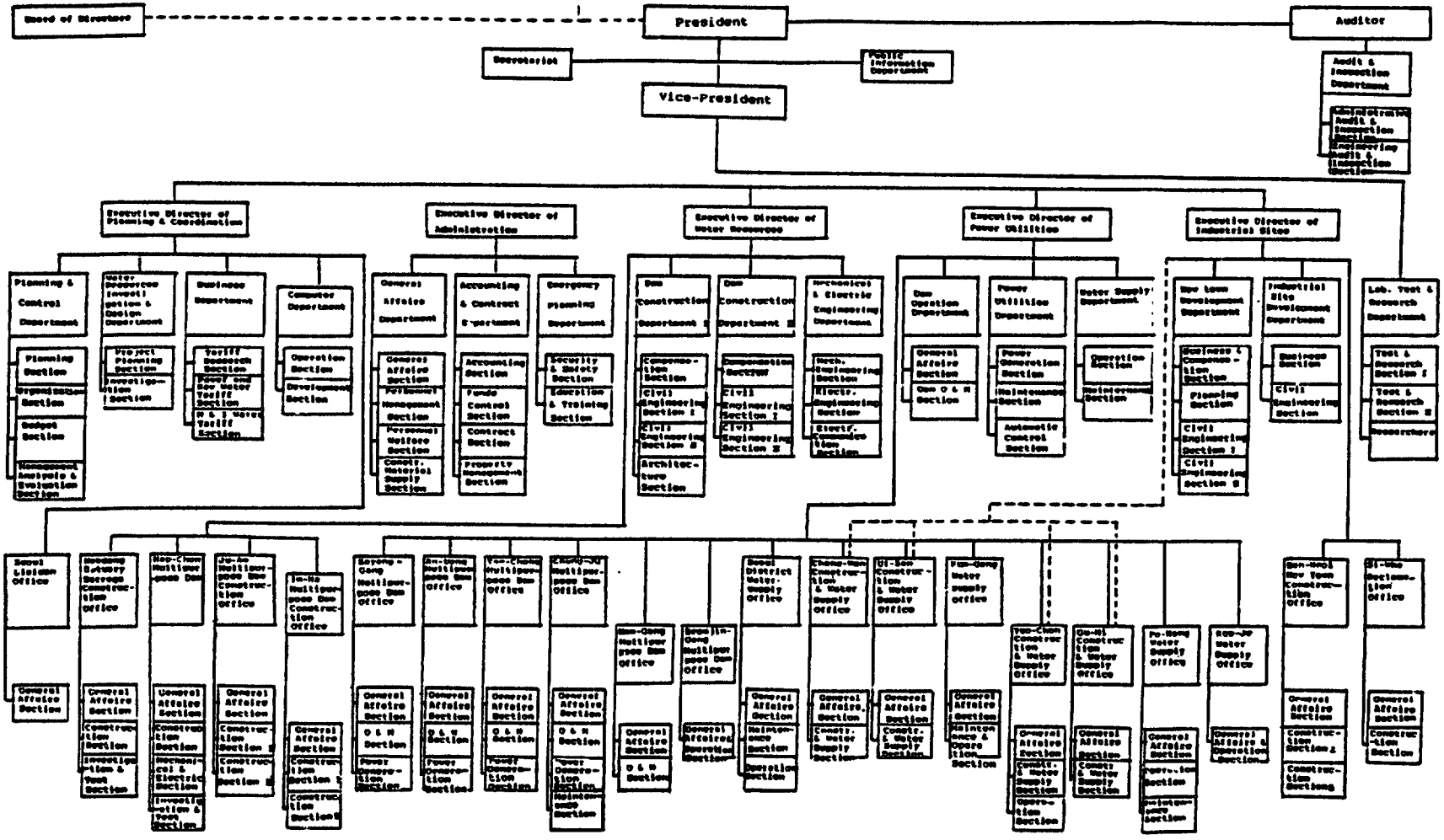
Appendix 19. MONTHLY GENERATION OF POWER

UNIT : MWh

YEAR	MONTH	GROSS ENERGY GENERATION AT CHUNGJU POWER STATION	AUXILIARY CONSUMPTION AT CHUNGJU POWER STATION	NET ENERGY SUPPLIED TO THE KEPCO SYSTEM
1985	MAY.	31,101	679	30,422
	JUN.	41,368	781	40,587
	JUL.	20,690	494	20,196
	AUG.	36,564	831	35,733
	SEPT.	135,000	2,734	132,266
	OCT.	125,276	2,516	122,760
	NOV.	81,519	1,941	79,578
	DEC.	36,640	1,225	35,415
	SUB-TOTAL	508,158	11,201	496,957
1986	JAN.	50,293	1,478	48,815
	FEB.	52,375	1,449	50,926
	MAR.	44,269	1,313	42,956
	APR.	44,929	1,214	43,715
	MAY.	37,885	1,081	36,804
	JUN.	40,645	1,178	39,467
	JUL.	57,481	1,476	56,005
	AUG.	129,036	2,707	126,329
	SEPT.	39,985	1,033	38,952
	OCT.	30,332	807	29,525
	SUB-TOTAL	527,230	13,736	513,494
	TOTAL	1,035,388	24,937	1,010,451

* This table was involved the gross energy generation and auxiliary consumption of power station No. 2 in Chungju Reregulation Dam

Appendix 20. ORGANIZATION OF I.S.W.A.C.O.



Appendix 21. PROPORTION OF REPLACEMENT COST

(THE DATA QUOTED FROM U.S.B.R)

ITEMS	PROPORTION OF REPLACEMENT (A)					PROLON.FAC.(B)	TOTAL
	~30 YEAR	~40 YEAR	~45 YEAR	~50 YEAR	TOTAL	OVER 50 YEARS	(A+B)
1.MAIN STRUCTURE	-	.0333	-	-	.0333	.9667	1.0000
2.POWER FACILITIES	.0870	.0530	.0220	.0870	.2490	.7510	1.0000
3.REREGULATION DAM	.0870	.0530	.0220	.0870	.2490	.7510	1.0000
4.BUILDINGS , ETC.	.0870	.0530	.0220	.0870	.2490	.7510	1.0000

IN CASE OF 10 % OF THE DISCOUNTING RATE

ITEMS	PERIOD	PROPORTION OF REPLACEMENT COST (A)	SINKING FUND FACTOR (B)	REPLACEMENT COST FACTOR (A)*(B)
1.MAIN STRUCTURE	~40 YEAR	.0333	.002259	.000075
2.POWER FACILITIES	~30 YEAR	.0870	.006079	.000529
REREGULATION DAM	~40 YEAR	.0530	.002259	.000120
BUILDINGS , ETC.	~45 YEAR	.0220	.001391	.000031
	~50 YEAR	.0870	.000859	.000075
TOTAL				.000755

Appendix 22. YEARLY WATER DEMAND PROJECTION AND BENEFITS

YEAR	DEMAND PROJECTION (MILLION cu m)			BENEFITS (MILLION US $)		
	M & I	IRRIGATION	TOTAL	M & I	IRRIGATION	TOTAL
1986	80.00	13.70	93.70	1.25	0.38	1.62
1987	163.00	27.39	190.39	2.54	0.75	3.29
1988	245.00	41.09	286.09	3.82	1.13	4.95
1989	419.00	54.78	473.78	6.53	1.51	8.04
1990	529.00	68.48	597.48	8.25	1.88	10.13
1991	631.40	82.17	713.57	9.84	2.26	12.10
1992	733.80	95.87	829.67	11.44	2.64	14.08
1993	836.20	109.57	945.77	13.04	3.01	16.05
1994	938.60	123.26	1,061.86	14.63	3.39	18.02
1995	1,041.00	136.96	1,177.96	16.23	3.77	20.00
1996	1,146.60	150.65	1,297.25	17.87	4.14	22.02
1997	1,252.20	164.35	1,416.55	19.52	4.52	24.04
1998	1,357.80	178.04	1,535.84	21.17	4.90	26.07
1999	1,463.40	191.74	1,655.14	22.81	5.27	28.09
2000	1,569.00	205.43	1,774.43	24.46	5.65	30.11
2001	1,691.60	219.13	1,910.73	26.37	6.03	32.40
2002	1,814.20	232.83	2,047.03	28.28	6.40	34.69
2003	1,936.80	246.52	2,183.32	30.19	6.78	36.98
2004	2,059.40	260.22	2,319.62	32.10	7.16	39.26
2005	2,182.00	273.91	2,455.91	34.02	7.54	41.55
2006	2,305.00	287.61	2,652.61	36.87	7.91	44.78
2007	2,548.00	301.30	2,849.30	39.72	8.29	48.01
2008	2,731.00	315.00	3,046.00	42.57	8.67	51.24
2009	2,731.00	315.00	3,046.00	42.57	8.67	51.24
2010	2,731.00	315.00	3,046.00	42.57	8.67	51.24
2011	2,731.00	315.00	3,046.00	42.57	8.67	51.24
2012	2,731.00	315.00	3,046.00	42.57	8.67	51.24
2013	2,731.00	315.00	3,046.00	42.57	8.67	51.24
2014	2,731.00	315.00	3,046.00	42.57	8.67	51.24
2015	2,731.00	315.00	3,046.00	42.57	8.67	51.24
2016	2,731.00	315.00	3,046.00	42.57	8.67	51.24
2017	2,731.00	315.00	3,046.00	42.57	8.67	51.24
2018	2,731.00	315.00	3,046.00	42.57	8.67	51.24
2019	2,731.00	315.00	3,046.00	42.57	8.67	51.24
2020~2034	2,731.00	315.00	3,046.00	42.57	8.67	51.24
AVERAGE	2,055.92	244.29	2,300.20	32.05	6.72	38.00
TOTAL	100,740.00	11,970.00	112,710.00	1,570.47	329.29	1,899.76

Appendix 23. YEARLY GROWTH RATE AND FLOOD CONTROL BENEFITS

YEAR	THE GROWTH RATE (%)		FLOOD CONTROL BENEFITS (MILLON US $)		
	SOUTH HAN	LOWER HAN	SOUTH HAN	LOWER HAN	TOTAL
1985	5 %	6 %	8.27	0.89	9.15
1986	|	|	8.68	0.94	9.62
1987	|	|	9.11	1.00	10.11
1988	|	|	9.57	1.06	10.63
1989	|	|	10.05	1.12	11.17
1990	|	|	10.55	1.19	11.74
1991	|	|	11.08	1.26	12.34
1992	|	|	11.63	1.33	12.97
1993	|	|	12.21	1.41	13.63
1994	|	|	12.82	1.50	14.32
1995	|	|	13.47	1.59	15.05
1996	|	|	14.14	1.68	15.82
1997	|	|	14.85	1.79	16.63
1998	|	|	15.59	1.89	17.48
1999	|	|	16.37	2.01	18.37
2000	|	6 %	17.19	2.13	19.31
2001	|	5 %	18.05	2.23	20.28
2002	|	|	18.95	2.34	21.29
2003	|	|	19.90	2.46	22.36
2004	|	|	20.89	2.58	23.47
2005	5 %	|	21.93	2.71	24.65
2006	4 %	|	22.81	2.85	25.66
2007	|	|	23.72	2.99	26.72
2008	|	|	24.67	3.14	27.81
2009	|	|	25.66	3.30	28.96
2010	|	5 %	26.69	3.46	30.15
2011	|	4 %	27.75	3.60	31.36
2012	|	|	28.86	3.75	32.61
2013	|	|	30.02	3.90	33.91
2014	|	|	31.22	4.05	35.27
2015	4 %	|	32.47	4.21	36.68
2016	3.5 %	|	33.60	4.38	37.99
2017	|	|	34.78	4.56	39.34
2018	|	|	36.00	4.74	40.74
2019	|	|	37.26	4.93	42.19
2020	|	4 %	38.56	5.13	43.69
2021	|	3.5 %	39.91	5.31	45.22
2022	|	|	41.31	5.49	46.80
2023	|	|	42.75	5.68	48.44
2024	|	|	44.25	5.88	50.13
2025	3.5 %	|	45.80	6.09	51.89
2026~2034	4 %	3.5 %	47.17	6.30	53.48
AVERAGE			28.85	3.76	32.61
TOTAL			1,442.65	187.89	1,630.54

Appendix 24. ECONOMIC REANALASIS FOR THE CHUNG JU MULTI-PURPOSE PROJECT

UNIT : US $ MILLION

	YEAR	COSTS			BENEFITS				
		CAPITAL	O.M & R	TOTAL	POWER	M & I	IRRIGATION	FLOOD	TOTAL
1	1978	2.50		2.50					0.00
2	1979	1.20		1.20					0.00
3	1980	27.70		27.70					0.00
4	1981	67.70		67.70					0.00
5	1982	102.90		102.90					0.00
6	1983	191.90		191.90					0.00
7	1984	124.80		124.80					0.00
8	1985	69.20	4.38	73.58	73.01			9.15	82.17
9	1986		4.38	4.38	73.01	1.25	0.38	9.62	84.26
10	1987		4.38	4.38	73.01	2.54	0.75	10.11	86.42
11	1988		4.38	4.38	73.01	3.82	1.13	10.63	88.59
12	1989		4.38	4.38	73.01	6.53	1.51	11.17	92.22
13	1990		4.38	4.38	73.01	8.25	1.88	11.74	94.88
14	1991		4.38	4.38	73.01	9.84	2.26	12.34	97.45
15	1992		4.38	4.38	73.01	11.44	2.64	12.97	100.06
16	1993		4.38	4.38	73.01	13.04	3.01	13.63	102.69
17	1994		4.38	4.38	73.01	14.63	3.39	14.32	105.36
18	1995		4.38	4.38	73.01	16.23	3.77	15.05	108.06
19	1996		4.38	4.38	73.01	17.87	4.14	15.82	110.86
20	1997		4.38	4.38	73.01	19.52	4.52	16.63	113.69
21	1998		4.38	4.38	73.01	21.17	4.90	17.48	116.56
22	1999		4.38	4.38	73.01	22.81	5.27	18.37	119.48
23	2000		4.38	4.38	73.01	24.46	5.65	19.31	122.44
24	2001		4.38	4.38	73.01	26.37	6.03	20.28	125.69
25	2002		4.38	4.38	73.01	28.28	6.40	21.29	128.99
26	2003		4.38	4.38	73.01	30.19	6.78	22.36	132.35
27	2004		4.38	4.38	73.01	32.10	7.16	23.47	135.75
28	2005		4.38	4.38	73.01	34.02	7.54	24.65	139.21
29	2006		4.38	4.38	73.01	36.87	7.91	25.66	143.46
30	2007		4.38	4.38	73.01	39.72	8.29	26.72	147.74
31	2008		4.38	4.38	73.01	42.57	8.67	27.81	152.07
32	2009		4.38	4.38	73.01	42.57	8.67	28.96	153.21
33	2010		4.38	4.38	73.01	42.57	8.67	30.15	154.40
34	2011		4.38	4.38	73.01	42.57	8.67	31.36	155.61
35	2012		4.38	4.38	73.01	42.57	8.67	32.61	156.86
36	2013		4.38	4.38	73.01	42.57	8.67	33.91	158.17
37	2014		4.38	4.38	73.01	42.57	8.67	35.27	159.52
38~57	2015~2034		4.38	4.38	73.01	42.57	8.67	36.68	160.94
AVERAGE			4.38	14.15	73.01	32.05	6.72	33.09	144.87
TOTAL		587.90	218.84	806.74	3,650.68	1,570.47	329.29	1,630.54	7,180.98

ECONOMIC RATE OF RETURN = 13.91%

Appendix 25. RESULTS OF SENSITIVITY TEST (CASE.1)

UNIT : US $ MILLION

	YEAR	COSTS			BENEFITS				
		CAPITAL	O.M & R	TOTAL	POWER	M & I	IRRIGATION	FLOOD	TOTAL
1	1978	2.50		2.50					0.00
2	1979	1.20		1.20					0.00
3	1980	27.70		27.70					0.00
4	1981	67.70		67.70					0.00
5	1982	102.90		102.90					0.00
6	1983	191.90		191.90					0.00
7	1984	124.80		124.80					0.00
8	1985	69.20	4.38	73.58	73.01			9.15	82.17
9	1986		4.38	4.38	73.01	1.25	0.54	9.62	84.42
10	1987		4.38	4.38	73.01	4.00	1.08	10.11	88.21
11	1988		4.38	4.38	73.01	6.76	1.62	10.63	92.02
12	1989		4.38	4.38	73.01	9.51	2.17	11.17	95.86
13	1990		4.38	4.38	73.01	12.27	2.71	11.74	99.73
14	1991		4.38	4.38	73.01	15.02	3.25	12.34	103.62
15	1992		4.38	4.38	73.01	17.78	3.79	12.97	107.55
16	1993		4.38	4.38	73.01	20.53	4.33	13.63	111.51
17	1994		4.38	4.38	73.01	23.29	4.87	14.32	115.50
18	1995		4.38	4.38	73.01	26.04	5.42	15.05	119.53
19	1996		4.38	4.38	73.01	28.80	5.96	15.82	123.59
20	1997		4.38	4.38	73.01	31.55	6.50	16.63	127.70
21	1998		4.38	4.38	73.01	34.31	7.04	17.48	131.84
22	1999		4.38	4.38	73.01	37.06	7.58	18.37	136.03
23	2000		4.38	4.38	73.01	39.82	8.12	19.31	140.27
24	2001		4.38	4.38	73.01	42.57	8.67	20.28	144.53
25	2002		4.38	4.38	73.01	42.57	8.67	21.29	145.55
26	2003		4.38	4.38	73.01	42.57	8.67	22.36	146.61
27	2004		4.38	4.38	73.01	42.57	8.67	23.47	147.73
28	2005		4.38	4.38	73.01	42.57	8.67	24.65	148.90
29	2006		4.38	4.38	73.01	42.57	8.67	25.86	149.91
30	2007		4.38	4.38	73.01	42.57	8.67	26.72	150.97
31	2008		4.38	4.38	73.01	42.57	8.67	27.81	152.07
32	2009		4.38	4.38	73.01	42.57	8.67	28.96	153.21
33	2010		4.38	4.38	73.01	42.57	8.67	30.15	154.40
34	2011		4.38	4.38	73.01	42.57	8.67	31.36	155.61
35	2012		4.38	4.38	73.01	42.57	8.67	32.61	156.86
36	2013		4.38	4.38	73.01	42.57	8.67	33.91	158.17
37	2014		4.38	4.38	73.01	42.57	8.67	35.27	159.52
38~57	2015~2034		4.38	4.38	73.01	42.57	8.67	36.68	160.94
	AVERAGE		4.38	14.15	73.01	35.83	7.34	33.09	149.27
	TOTAL	587.90	218.84	806.74	3,650.68	1,755.53	359.61	1,630.54	7,396.37

ECONOMIC RATE OF RETURN = 14.49 %

Appendix 26. RESULTS OF SENSITIVITY TEST (CASE 2)

UNIT : US $ MILLION

	YEAR	COSTS			BENEFITS				
		CAPITAL	O.M & R	TOTAL	POWER	M & I	IRRIGATION	FLOOD	TOTAL
1	1978	2.50		2.50					0.00
2	1979	1.20		1.20					0.00
3	1980	27.70		27.70					0.00
4	1981	67.70		67.70					0.00
5	1982	102.90		102.90					0.00
6	1983	191.90		191.90					0.00
7	1984	124.80		124.80					0.00
8	1985	69.20	4.38	73.58	73.01			9.15	82.17
9	1986		4.38	4.38	73.01	0.76	0.23	9.62	83.63
10	1987		4.38	4.38	73.01	1.89	0.46	10.11	85.47
11	1988		4.38	4.38	73.01	3.02	0.68	10.63	87.35
12	1989		4.38	4.38	73.01	4.15	0.91	11.17	89.25
13	1990		4.38	4.38	73.01	5.28	1.14	11.74	91.18
14	1991		4.38	4.38	73.01	6.41	1.37	12.34	93.13
15	1992		4.38	4.38	73.01	7.54	1.60	12.97	95.12
16	1993		4.38	4.38	73.01	8.67	1.82	13.63	97.14
17	1994		4.38	4.38	73.01	9.80	2.05	14.32	99.19
18	1995		4.38	4.38	73.01	10.93	2.28	15.05	101.28
19	1996		4.38	4.38	73.01	12.06	2.51	15.82	103.41
20	1997		4.38	4.38	73.01	13.19	2.74	16.63	105.58
21	1998		4.38	4.38	73.01	14.32	2.96	17.48	107.78
22	1999		4.38	4.38	73.01	15.45	3.19	18.37	110.03
23	2000		4.38	4.38	73.01	16.58	3.42	19.31	112.33
24	2001		4.38	4.38	73.01	17.71	3.65	20.28	114.65
25	2002		4.38	4.38	73.01	18.84	3.88	21.29	117.03
26	2003		4.38	4.38	73.01	19.97	4.10	22.36	119.45
27	2004		4.38	4.38	73.01	21.10	4.33	23.47	121.92
28	2005		4.38	4.38	73.01	22.23	4.56	24.65	124.46
29	2006		4.38	4.38	73.01	23.36	4.79	25.66	126.83
30	2007		4.38	4.38	73.01	24.49	5.02	26.72	129.24
31	2008		4.38	4.38	73.01	25.62	5.24	27.81	131.70
32	2009		4.38	4.38	73.01	26.75	5.47	28.96	134.20
33	2010		4.38	4.38	73.01	27.88	5.70	30.15	136.75
34	2011		4.38	4.38	73.01	29.01	5.93	31.36	139.31
35	2012		4.38	4.38	73.01	30.14	6.16	32.61	141.93
36	2013		4.38	4.38	73.01	31.27	6.39	33.91	144.59
37	2014		4.38	4.38	73.01	32.40	6.61	35.27	147.30
38~57	2015~2034		4.38	4.38	73.01	33.53	6.84	36.68	150.07
	AVERAGE		4.38	14.15	73.01	26.36	5.39	33.09	137.86
	TOTAL	587.90	218.84	806.74	3,650.68	1,291.75	264.29	1,630.54	6,837.26

ECONOMIC RATE OF RETURN = 13.41 %